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Re-engineer Internal Supply Chain/Material Delivery Process

Final Report

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Table of Contents

1 **INTRODUCTION** **3**
1.1 Project Scope 3
1.2 Project Analysis 4
1.3 Shipyard "Factory" Growth 5
1.4 Receiving 6
1.5 Warehousing 7
1.6 Shipyard Material Movement 8
1.7 WIP Movement 17
1.8 WIPS to Dock 21
1.9 Move on ship 22
2 **Material Tracking** **23**
2.1 IT Technology 24
2.2 Technology Overview 24
2.3 Purpose 25
2.4 ATT Application Standards in Other Industries 25
2.5 ATT Media and supporting technologies 26
2.6 Smart Cards (Also known as Common Access Cards (CAC) 33
2.7 Satellite-Tracking 33
2.8 Potential ATT applications 33
2.9 DoD Unique Identification of Tangible Items 35
2.10 ATT in the DoD Supply Chain 39
2.11 Wireless LAN (WLAN) 40
3 **Integrated Supply Chain System Concept** **42**
3.1 Requirements 42
3.2 Benefits: 43
3.3 Barcode Symbologies 44
3.4 Wireless Network Standard 44
3.5 Access Points 44
3.6 Barcode Scanning Equipment 44
3.7 Barcode Labeling & Marking Equipment 45

3.8 Recommended Pilot Architecture 45
4 Other industries 46
4.1 Aircraft Manufacturing 46
4.2 Airlines 46
4.3 Automotive 47
4.4 Construction 47
4.5 Package Delivery 47

1 INTRODUCTION

The evolution of a shipyard normally covers a span of generations. During that time the yard may see changes that are caused due to: the types of ships being built at a given time; constraints due to land size or configuration; and other changing influences.

As the shipyard evolves it becomes a grouping of multiple manufacturing operations with some housed in their own facility. Each of these facilities may rival the manufacturing operations of other companies in size and complexity. Flow patterns within each of these shipyard facilities are, like manufacturing operations of other industries, a prime concern.

However, while the evolution progresses the fact that a shipyard is a factory without walls or roof may become lost in the effort to keep up with growth. Concentration is given to the flow within the separate manufacturing facilities but the major flow of the "shipyard factory" may be lost. This can create a situation where cross flows and counter flows are created. These cross flows impact the efficiency of the shipyard and add costs to its operation. Also, these cross flows, counter flows, and the inefficiencies created may develop situations where materials are misplaced and therefore create disruptions in the planned workflow. Therefore, to control costs and efficiencies the focus of a shipyard as a factory is important so the proper flow of material and products through the shipyard factory is not disrupted and, proper tracking mechanisms must be utilized to prevent material misplacement.

1.1 Project Scope

Misplacement of material and data in a ship-focused organization can create considerable disruption in the workflow. The requirements of where the material is needed and when are critical to the successful completion of the vessel. Delays in providing such also create similar disruption. Both misplacement and delay increase costs. Duplicate material may be purchased or manufactured; duplicate data may be created. Both situations increase costs.

While misplacement and delay increase cost, loss of material or data is even more costly to the organization. Misplacement may create the re-manufacture or re-purchase of an item with the intent that the misplaced item will be used in another location in the existing vessel or used on a follow vessel. Lost material cannot be utilized in another location or ship.

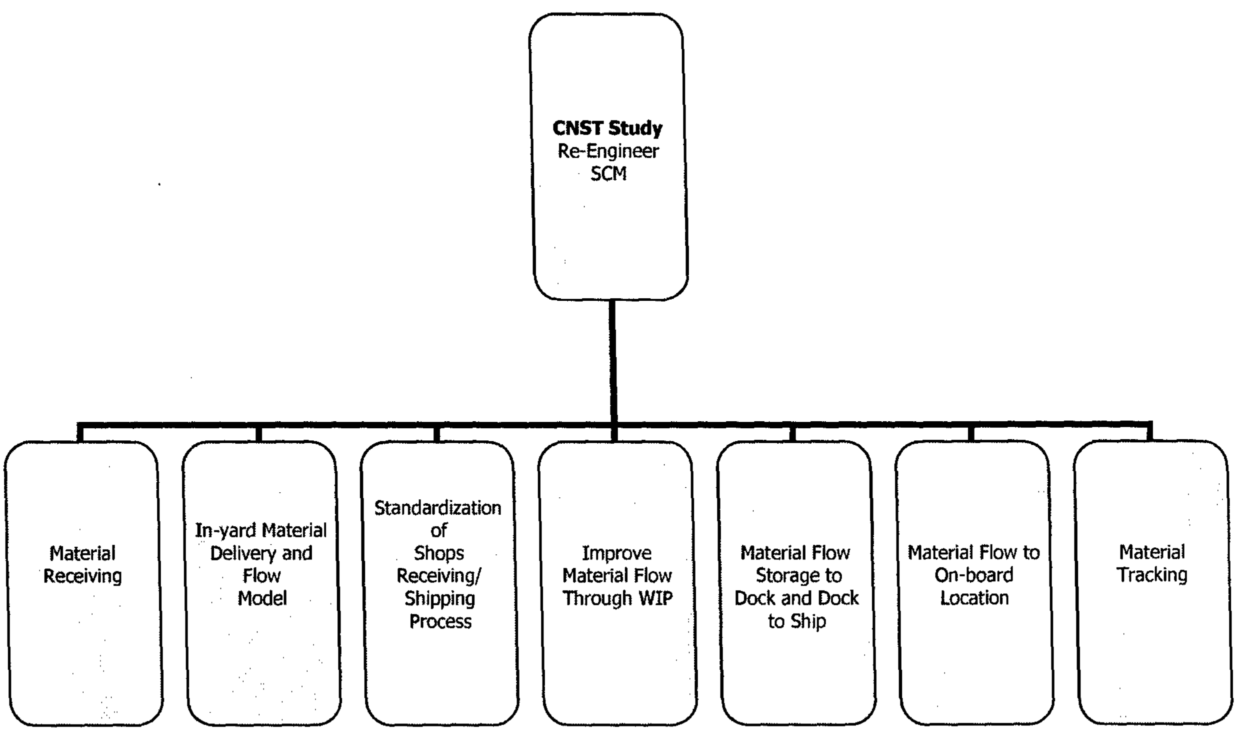
Additionally, the timely flow of material and data is critical to organization processes. Delays in these flows can create undue cost by creating a temporary lack of materials, tools, or data at a work station, increased in-process inventory levels, unplanned reallocation of workers, etc. These situations need to be avoided in the organization.

With today's management techniques and technologies, the development of a total system to eliminate these problems is now attainable in the complex environment of U.S. Navy ship construction. Such a system would include mechanisms to treat material movement with similar

professionalism as other major construction tasks: to discretely plan and schedule, efficiently execute, and continuously monitor the material movement process. Applying such discipline, lean principles, and information management technology in an integrated-systems approach would set a high standard in improving material flow and reducing misplacement or loss.

1.2 Project Analysis

While Six Sigma has garnered its reputation as a valuable analysis tool in the manufacturing arena, the use of Six Sigma techniques can also provide the methods to analyze existing material storage and movement situations. This project was subdivided into Six Sigma focus areas with a Six Sigma Black Belt in charge of each of these areas).



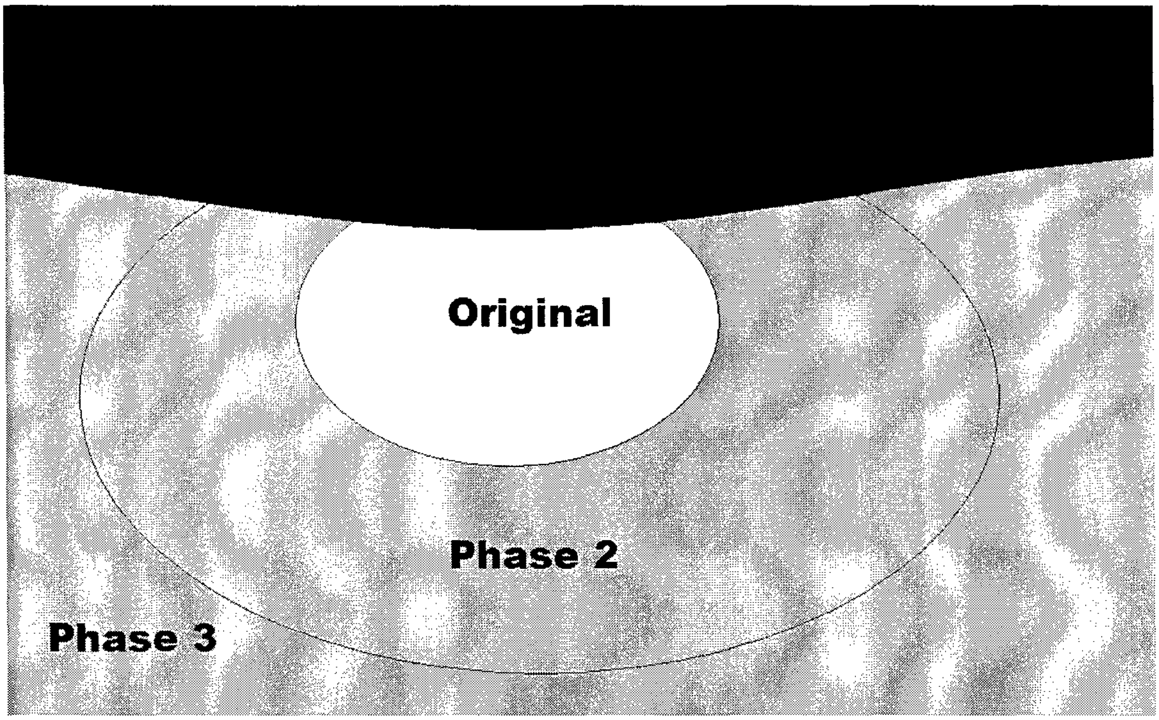
Project Structure

One of the outcomes of structuring the project in such a manner was the development of a central data base of Value Stream Maps (VSM). This was initially done to consolidate all of the process flow diagrams and VSM into one area where all project leads and teams could access them as needed. This created a very useful resource tool and provided the assurance that all were working to the latest diagram. This library was then opened to all process improvement groups and others who needed process information. The outcome of this is that the VSM library is being utilized by several groups, in addition to the process improvement areas, as a resource base:

- ERP project team to understand processes and compare to the various ERP modules.
- Mentoring/training program to explain processes of an area.
- Other BB & GB project teams to support their efforts.
- Other departments to understand process flows and how organizations interface/interact.

1.3 Shipyard "Factory" Growth

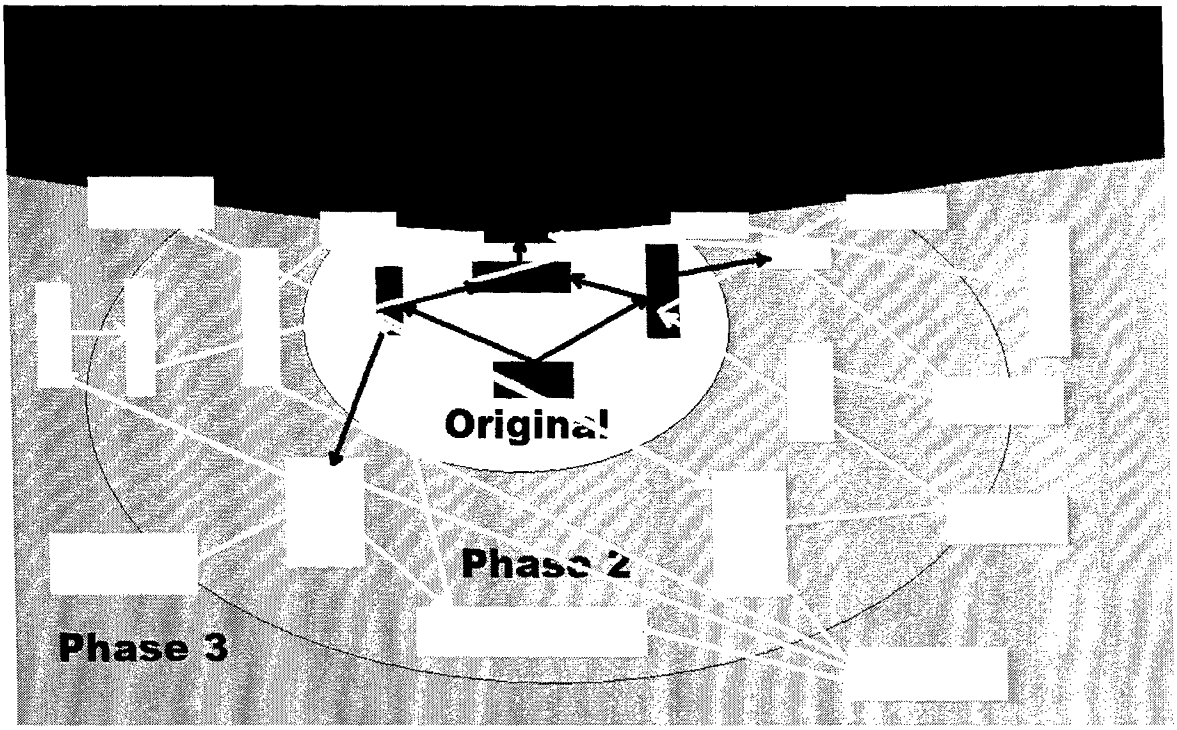
Shipyards normally were not built for their current needs. Most have evolved over the years to be what they are today. Many which originally were built on a specific piece of land have exceeded the capacity of that land area and have had to acquire additional acreage. In many cases this expansion was accomplished in stages (see Figure 2).



Shipyard Growth

There are also cases where the additional expansion was not adjacent to the existing property and required the operations to be split. In many cases, even where the operations were contiguous, the expansion created inefficiencies within the operation.

Many operations developed cross flows and back flows due to inefficient expansion creating considerable back and forth movement of delivery vehicles and personnel which, in turn causes excessive travel times.



Evolved Shipyard Flow

It is imperative that these inefficiencies be identified and improved. The application of Industrial Engineering, Lean, and Six Sigma methods can help identify and improve inefficient operations created by expansions of the past. This project provides an overview of the application of these tools to the improvement of a shipyard supply chain operation.

1.4 Receiving

The automation of any manual data entry operation is paramount in the improvement of receiving efficiency and allows the receiving operation to reduce errors. This is accomplished by reducing the margin for human error, reducing the number of shipments noted as "no Purchase Order" and speeding up the logging process.

To improve receiving operations, a bar code and scanning system must be utilized. Bar code label must be applied to the items being received. If the supplier can provide such a label, or labels can be provided to the supplier, the ability to track material from the manufacturing location through the receiving operation, and beyond, can be accomplished. Otherwise, labels will need to be attached as part of the receiving operation.

Suppliers (70% according to survey information) are willing and, in most cases, able to provide material with bar codes already attached. It is highly probable that the bar codes utilized by a supplier will meet the requirements of the shipyard.

However, poor packing list quality and non-compliance with the material marking requirements of the purchase documents also create receiving problems. These quality and marking problems slows down processing in the receiving operation; causes the creation of supplier exception reports; increases the number of shipments noted as "no Purchase Order"; and, contributes to the misidentification of material and causes extra effort throughout the operation.

From supplier surveys, it was found that almost 100% of suppliers believe they provide packing lists that include the required information as specified in the purchasing documents. They did admit that units of measure may differ and that they do have problems with third party shipments. Suppliers also believe that they adequately mark their material as per the specifications outlined in the purchasing documents.

If a supplier does not have bar coding capabilities, a Universal Packing List can be provided. This would help alleviate some of the problems created from suppliers believing they are meeting the requirements of the purchase documents when, in reality, they aren't meeting those requirements. Vendors which did not have bar coding capability were more enthusiastic about a Universal Packing List scenario. Those that had bar coding capability were willing to add bar codes to their own packing list.

Due to requirements related to the provisioning and maintenance of equipments it is imperative to capture as much information about the item in the receiving process. This would include item serial number at the receiving point. Capturing detailed information provides the ability to track the material to its final destination aboard ship and log provisioning information for the item, its serial number, its end location, and any maintenance performed on the equipment.

1.5 Warehousing

While the focus of the project is the movement of material, it is important that various aspects of the total operation be reviewed. Therefore, the storage of material and its movement within the facility was of consideration but not part of its major focus.

Warehousing operations which were developed many years ago may not have changed much over the years. In many cases storage equipment has been modified to conform to the items being handled. However, these modifications may not be the most efficient methods of storing current equipment. Usually the modifications just enable one type of equipment to be used to store more item configurations in a less efficient manner. As an example, a pallet rack may be modified to be able to handle shelf type items instead of creating an area for shelving materials. Of course, when this occurs, the cubic capacity of the warehouse suffers as does the efficiency of item/location storage application, and storage and picking operations. This also creates excessive movement and handling of materials. In most warehouses of more than 15 – 20 years

in age considerable streamlining in the storage philosophy, storage methodology, equipment types, and systems can be accomplished.

The inbound visibility of incoming shipments is a key part in having a warehouse which is responsive to needs as opposed to reactive to needs. A synchronous set of processes which include advanced shipment notices and staff/equipment planning can be the factor to make a warehouse highly responsive to items that arrive on the shipping dock.

The control of material flow into the shipyard begins when the material requirements are generated. The needs of the shipyard, such as when to take possession of inbound inventory and the amount of inbound inventory which can be processed and stored, is critical to the efficient working of the warehouse. The ability to have inbound items identified so the proper personnel are available, required equipments needed to move material are prescheduled, and storage locations are assigned is also required . These factors must be coordinated from the time material requirements are generated and purchase orders placed. The system which monitors the various processes must consider all of these aspects and put them into alignment.

1.6 Shipyard Material Movement

This portion of the project was to reduce delivery time and distance by evaluating a systematic route/philosophy for material delivery and rearrange locations for better efficiency. This material movement portion encompassed the following aspects:

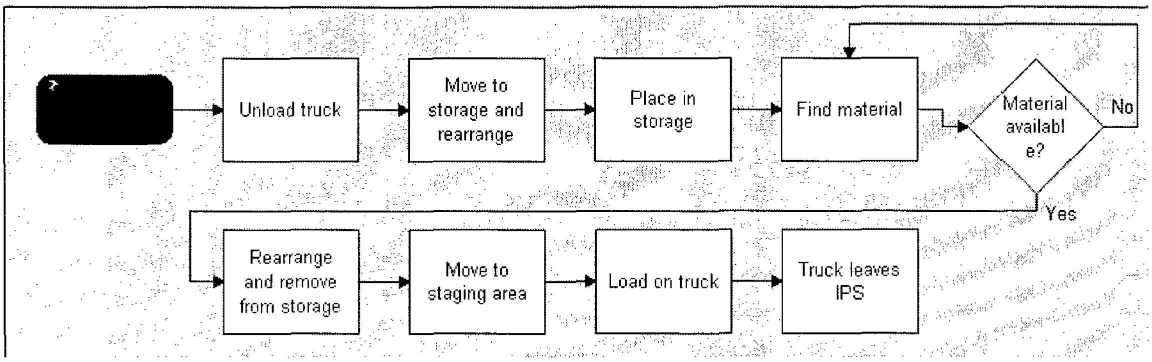
- Apply a simulation tool
- Develop logical material delivery flow
- Determine most efficient locations
- Reduce Distance and Time

1.6.1 Apply a Simulation Tool

One of the first tasks was to select a tool which could be used to: develop process flows, create value stream maps, calculate rolled throughput yields, calculate defects per million and other Six Sigma factors, and develop and analyze "what if scenarios".

One of the tools in the final evaluation was iGrafx (Figure 4) which is a proprietary software package that provides many Six Sigma analysis tools. This package:

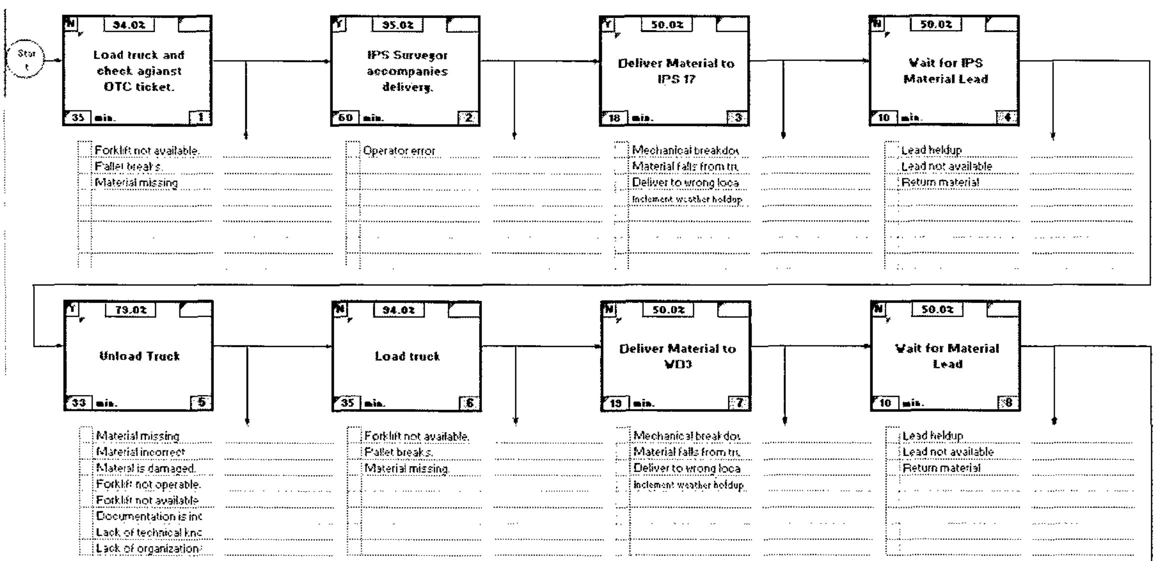
- creates value stream maps
- provides a virtual graphics simulation tool
- allows "what if" games
- calculates Six Sigma factors
- requires a per user software cost of ~$1500



iGrafx Virtual Simulation Diagram

The other tool which was in the final evaluation was a home grown Excel based Six Sigma calculator. This tool:

- creates value stream maps
- allows "what if" games
- calculates Six Sigma factors
- is virtually free and every shipyard computer has access to the software
- was within 1 – 2% of the results provided by iGrafx



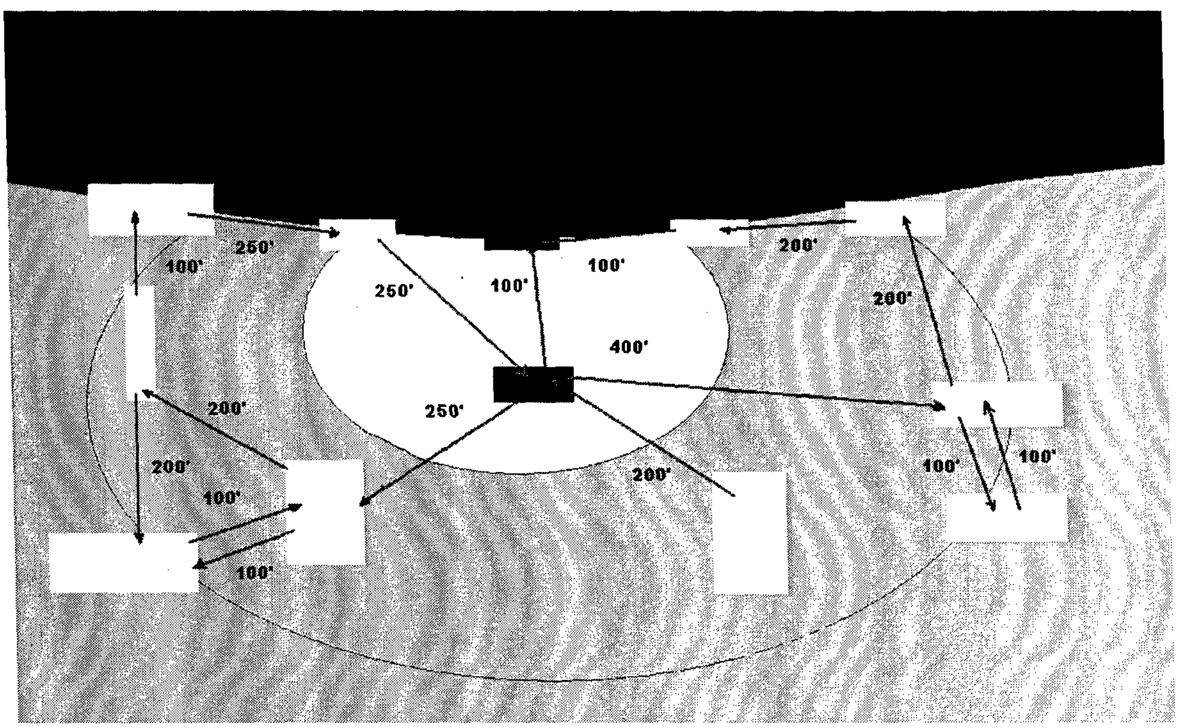
Excel Six Sigma Calculator

Both tools were used on a trial basis. The results showed that the Excel based tool aligned within 1-2 % of the iGrafx results. The iGrafx tool would be limited in availability due to the per user cost. While the Excel tool did not have a virtual graphics simulation, it was determined that

the graphics simulator of iGrafx did not offer any additional benefit. Therefore, the Excel tool was utilized throughout the project.

1.6.2 Develop Logical Material Delivery Flow

A Physical Process Flow Diagram can be utilized to ascertain the current flow patterns within the shipyard. This diagram can be developed in such a manner as to provide distances within the respective flow patterns. From this development, cross flows, back flows, distance traveled, and time expended can be identified. This analysis is pertinent to understanding what is transpiring in the shipyard.



Physical Process Flow Diagram

Upon completion of the Physical Process Flow Diagram, an analysis can be accomplished as to why cross flows and counter flows have developed in the shipyard.

During this analysis, times can be calculated for the travel distances so travel time costs can be part of the final analysis. In depth analysis is then accomplished on what changes can be done to eliminate cross flows, eliminate counter flows, and reduce travel time.

During the analysis relative to flow patterns, it is important to identify the reasons certain patterns have developed. There may be very logical and important reasons why some patterns developed. The understanding of flow pattern reasons is critical to the final analysis. Once this

understanding has been accomplished, work can begin on creating a flow pattern which makes sense, reduces travel time, and provides the proper service to the shipyard customer.

1.6.3 Determine Most Efficient Locations

While it may be a desire to relocate a building that doesn't quite fit into the most logical flow pattern, it is not really the most feasible solution to a flow problem. Therefore, cost tradeoff analysis must be accomplished to determine what can be relocated to help solve the flow pattern problem and what can't be relocated. In some cases it may not be facility relocation but shared use of material drop locations by multiple facilities which create the most efficient solution. Some of the solutions to the best flow pattern may create several smaller flow problems which must be solved to be able to create the most efficient locations and provide the best flow pattern for the shipyard.

Of course, there are locations which can be moved without tearing down and rebuilding a facility. Most shipyards have several open areas used as lay down spaces which may be down sized or eliminated. The materials which were being held there are distributed to other areas which fit into the most efficient flow pattern.

It is at this point that the simulation tool is brought into the study. The distance and time calculations to various locations can be entered into the tool to determine which flow pattern offers the most efficiency. There is no 100% efficient flow pattern as there will always be characteristics of the patterns that preclude meeting that goal. However, there can be a solution that, when considering all parameters and constraints, is the best.

1.6.4 Reduce Distance and Time

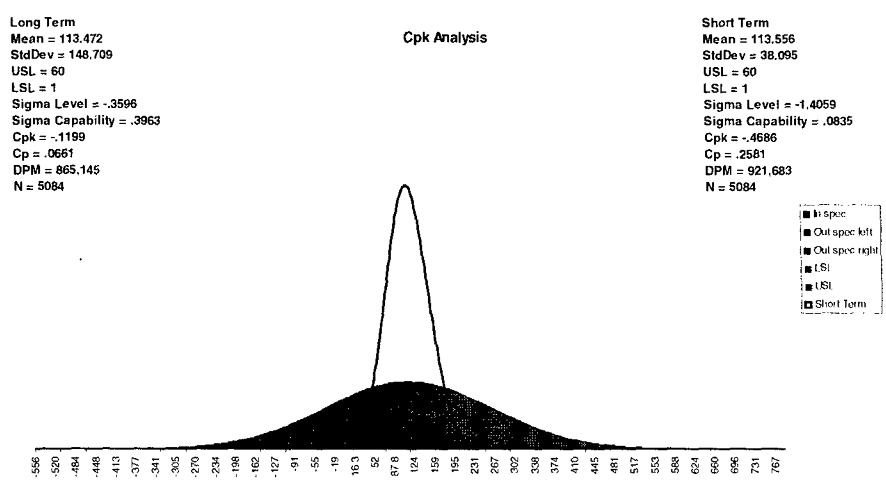
The main goal of the delivery flow analysis is to reduce travel distance and its related time. Once the simulation tool has been applied, the time and distance information is part of the output from the tool and before and after costs/time/distance is available.

However, the analysis is not complete at this point. There may be other aspects which must be considered in the development of the time and distance evaluation. One of these is storage considerations. The movement of material into and out of storage locations is as critical to the proper flow and movement analysis as is the movement of material from the manufacturing areas to the end use point. The creation of additional, non-value, material movement increases the cost component of SCM.

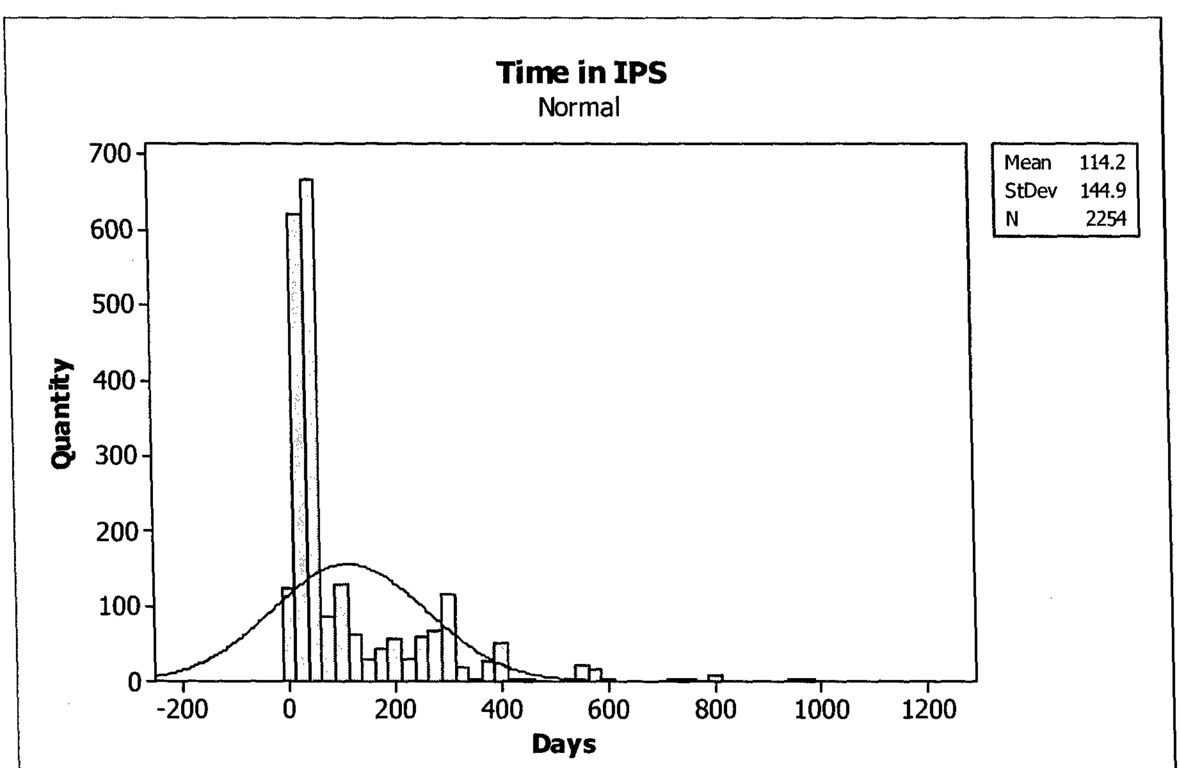
WIP must be reviewed and managed closely as high WIP creates additional inventory handling/ movement cost. WIP which exceeds allotted storage time can become damaged which requires movement of the material out of WIP to a repair location. There are inventory management

functions which also require excessive movements of personnel to the WIP. Some of these functions are cycle counts, inventory consolidation, inventory inspections, and other aspects of inventory management such as the need for special processes (rust removal, the addition of special wrapping or coating, etc.) if an item has been in inventory too long. These additional material movement processes and costs associated with high WIP inventory must be considered in evaluating and reducing material movements.

The length of time for items in WIP inventory can be analyzed with available Six Sigma tools. Charts can be developed to allow the analysis as to the health of the processes being used by the organization. One of those processes would be the length of time in storage.

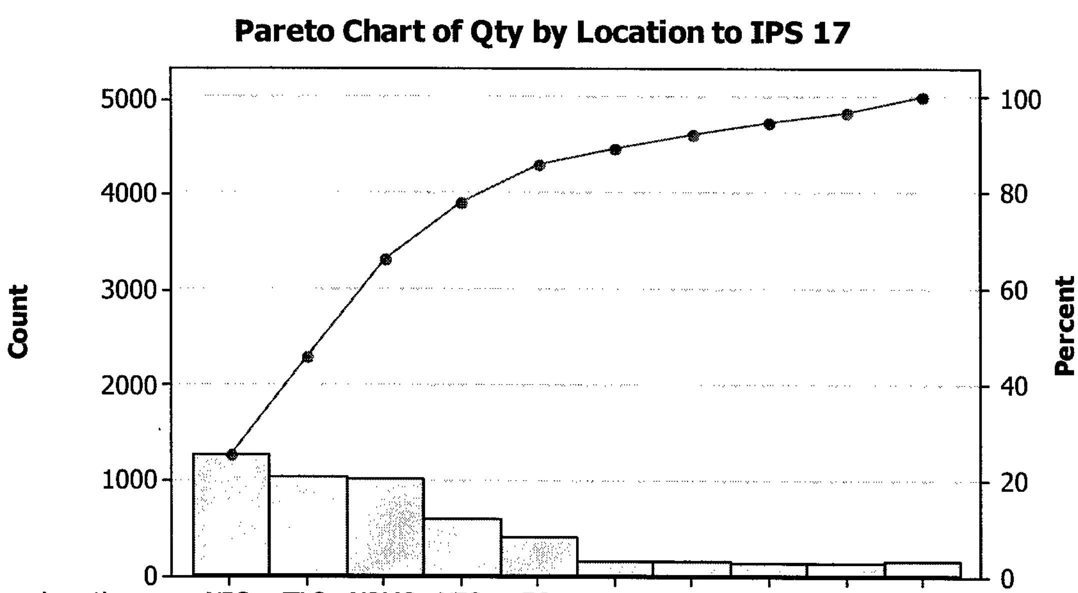


Cpk Analysis



As seen from the above two working graphs a determination can be made as to the time spent in storage against upper and lower limits (the maximum allowable number of days in storage – set at "60" in the above charts, and the minimum number of days in storage – set at "1"). The information provided will assist in the development of calculations to be applied to the initial findings to determine the true impact from the storage time constraints. This will provide the ability to consider the outside influence which impacts distance/time calculations.

Pareto charts provide a method of analysis which allows the breakdown of process activities into discrete segments. Each of these segments can then be analyzed as to its activities as it relates to the whole segment. These Pareto charts should be utilized as a guide in determining the logical stages of implementation. It allows the concentration of efforts on those items that have the largest impact on the process.

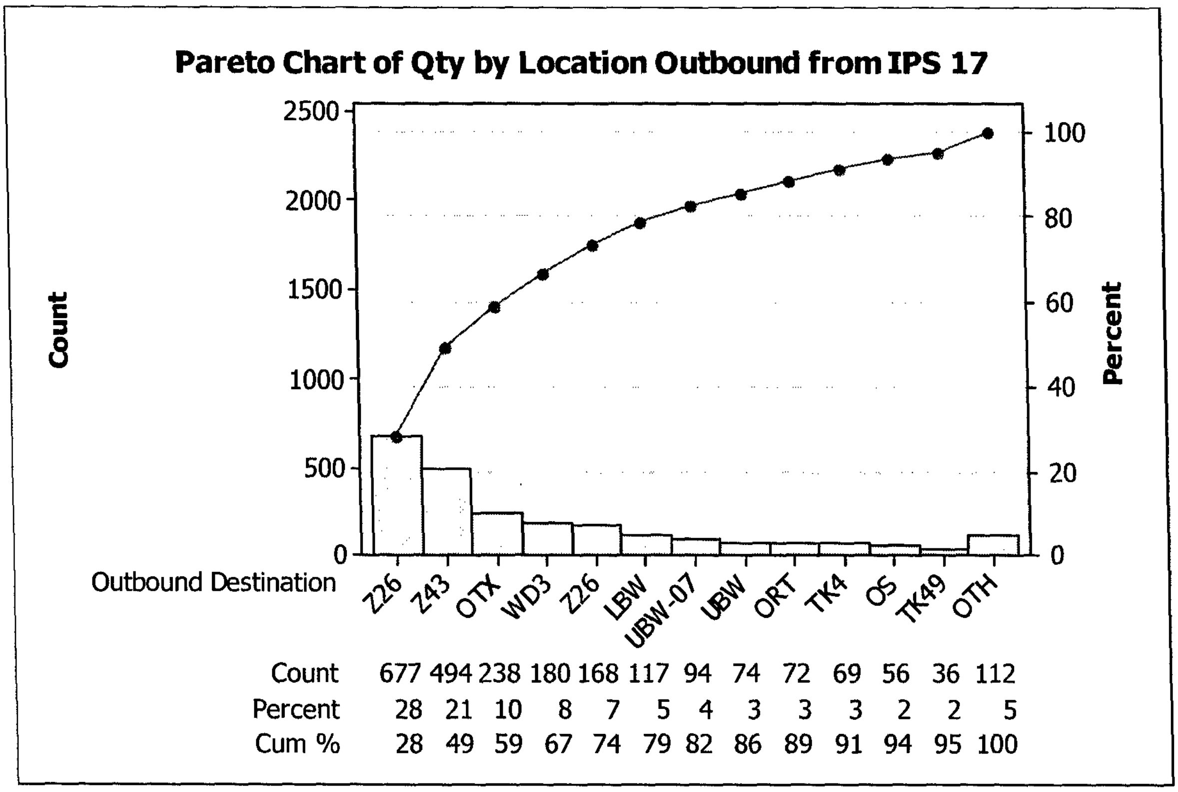


Locations	NPS	TLS	NSMS	NFS	FO	NP	PS	NPLS	NTMS	OTH
Count	1273	1026	1018	600	409	149	149	126	123	152
Percent	25.3	20.4	20.3	11.9	8.1	3.0	3.0	2.5	2.4	3.0
Cum %	25.3	45.8	66.0	78.0	86.1	89.1	92.0	94.5	97.0	100.0

Inbound Pareto Chart

In the above chart several scenarios can be developed. If the goal is to do an initial test implementation, selection can be made of those items with the lesser quantities (NP, PS, NPLS,

NTMS) and move those direct to the next user rather than to WIPS 17 first. After the initial test has been done and any problems worked out, an intermediate test can be done with higher volumes (adding NFS and FO). Based on the results of this intermediate test, implementation can be carried to the next level which would be the movement of all material direct to the next user and avoid WIPS 17 entirely. Of course, depending on test results, a combination which works best overall will be utilized.

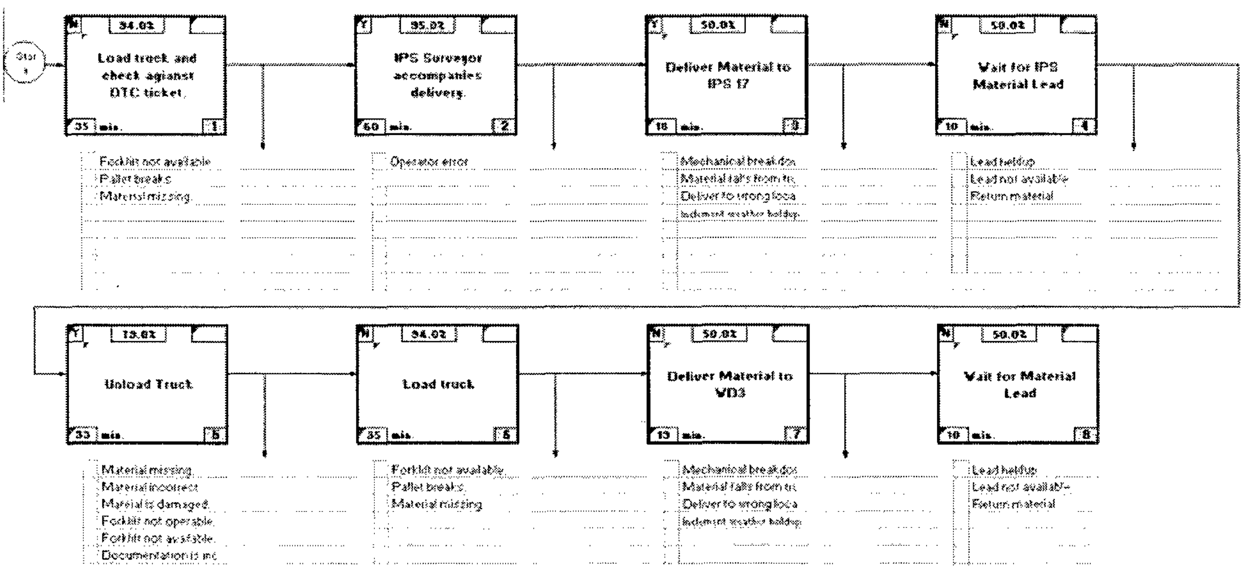


Outbound Pareto Chart

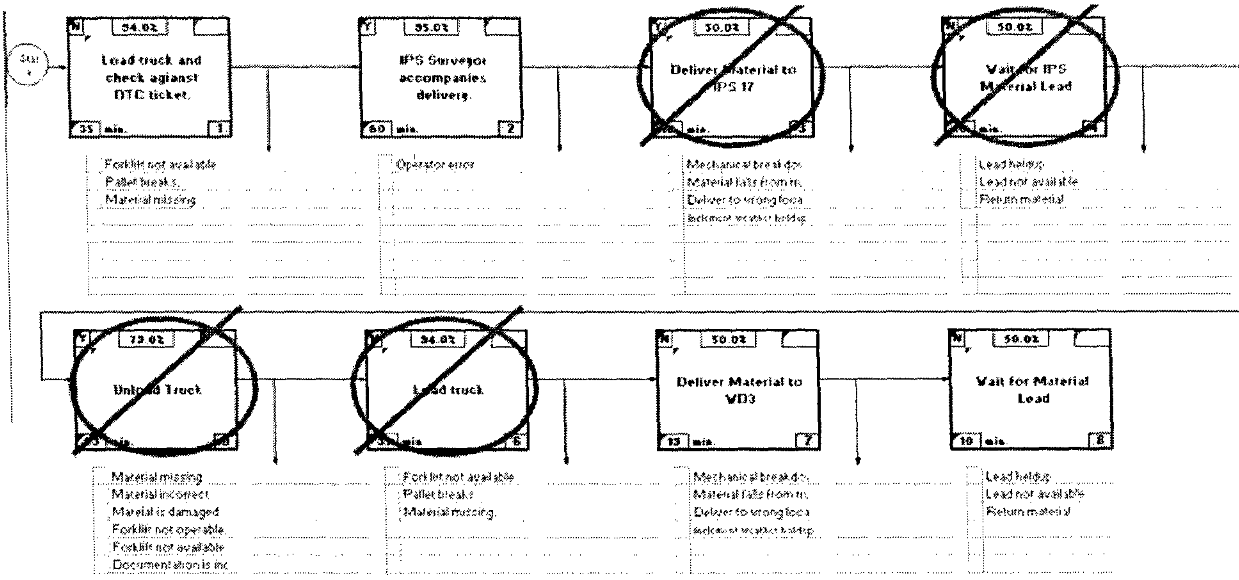
The above chart, used in conjunction with the Inbound Chart, reinforces those items which can be directly sent to a user organization and not be placed into WIPS 17.

These charts demonstrate that a large percentage of handling/moves could be deleted by sending items of lower volumes directly to the user. Also Point of Use (POU) delivery of materials coming in from outside sources should become the normal operational mode instead of being delivered to a WIP area and then distributed to the user. Therefore, the Pareto charts should be utilized as a guide in determining the logical stages of implementation since it becomes too costly to run material into and out of WIPS areas in-between processes. Direct movement to the next process area avoids excessive delivery, unloading, and loading operations and their associated costs. The use of a WIPS should be the exception rather than the rule. If a WIPS is required it should be a "finished parts storage area" adjacent to the ships. If the next process area is backed up a short-term staging area near that process area should be utilized.

The reduction in distance and time can be additionally expanded by doing a Value Stream Map (VSM) of the process. An initial VSM ("As Is") is created of the existing process flow. A team of process owners/users is organized for the purpose of reviewing the process flow and making recommendations for change. These recommendations are incorporated into a revised VSM which then demonstrates the changed ("To Be") process flow. These VSMs are demonstrated in the graphics below.



"As Is" Process

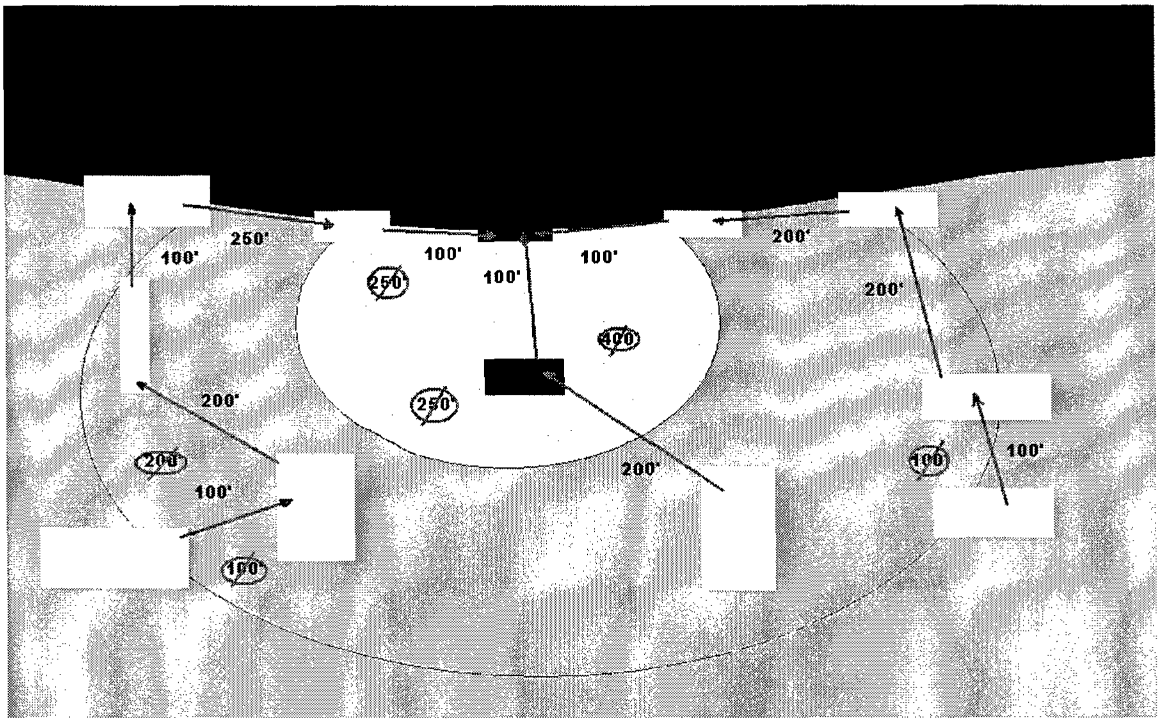


"To Be" Process

The changed process flow will have positive cost impacts as well as positive flow impacts on the operations. The new flow will have processes that are eliminated as well as process times that have been reduced all due to revisions to the existing processes. These process changes, along with the changes created from the delivery of material direct to the next user, and any changes in facility utilization will create an improvement in the Physical Process Flows.

These improvements in process flows can be demonstrated graphically by doing a revised Physical Process Flow Diagram. This diagram will incorporate any and all changes developed during the VSM reviews and the material flow reviews.

A revised Physical Process Flow Diagram is demonstrated in the graphic below. It should be noted that visual means are used to show those distances which have been eliminated. The eliminated distances, time to travel the distance, and number of movements along those eliminated distances are used to calculate the costs that are no longer incurred.



Improved/Revised Physical Process Flow Diagram

1.7 WIP Movement

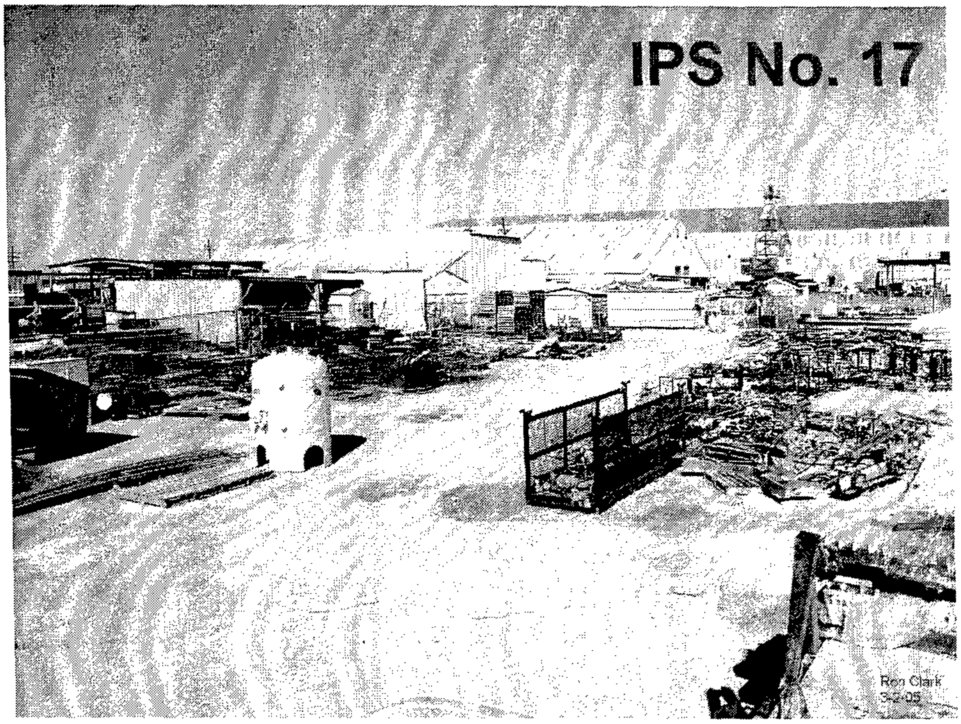
It is important to evaluate movement of material within the work in-process areas. Controls need to be invoked in these areas to eliminate excessive movement of material in and out of WIPS, provide direct access identifiable areas for material storage, and provide timely information.

Since raw materials take up large portions of real estate within the overall shipyard, storage methods should be updated to reduce the overall space requirements and operations costs. This can be done by using rules-based slotting, consolidating multiple fixed storage locations to eliminate honey-combing, focusing direction on reducing inventory in all areas by moving shop storages to minimum manageable levels, and moving materials directly from their origin to the point of use with no intermediate buffer zone.

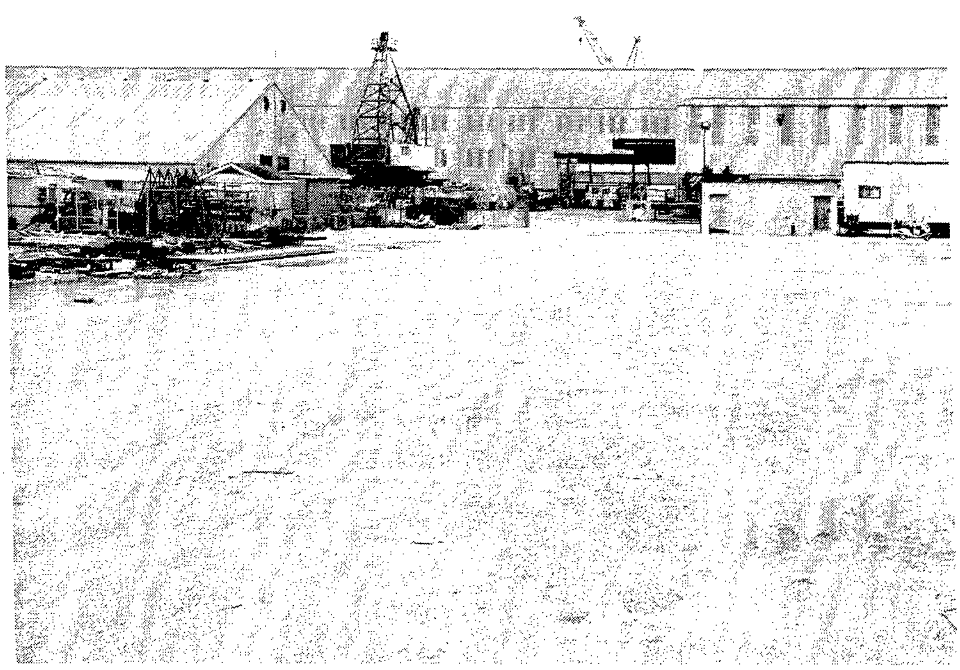
Consideration should also be given to operate on a pull basis to reduce the amount of stored material in WIPS and move toward avoiding WIP storage practices for most manufactured items. This can be best accomplished by moving towards JIT (just-in-time) delivery direct to the point of use, of both in-yard manufactured materials as well as supplier provided materials. And, 5-S initiatives should also be incorporated as well as improved location identification techniques.

Some photos of changes incorporated are presented below. As can be seen, considerable clean-up of the areas were accomplished using 5-S processes. The benefits from this were not only

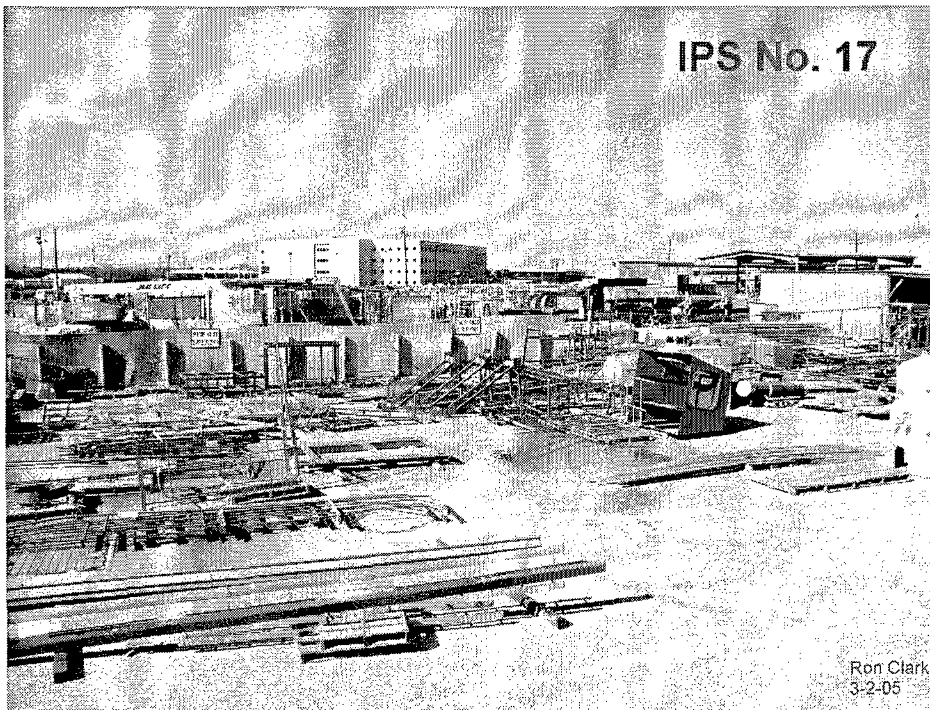
visual in nature but also provided improvements in the identification, sorting, and tracking of material.



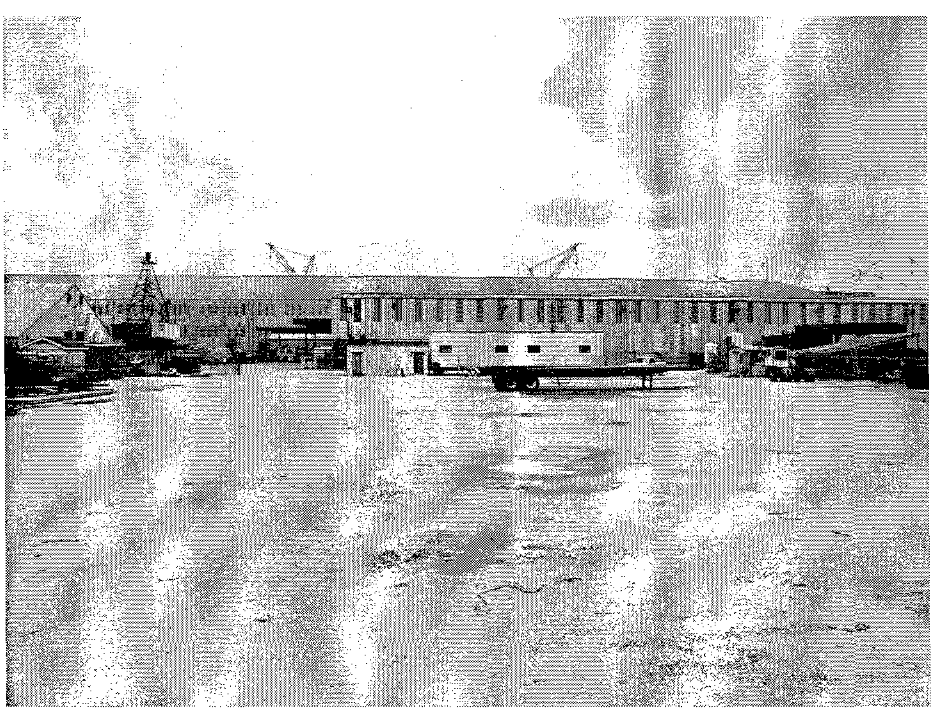
Receiving Area - Before



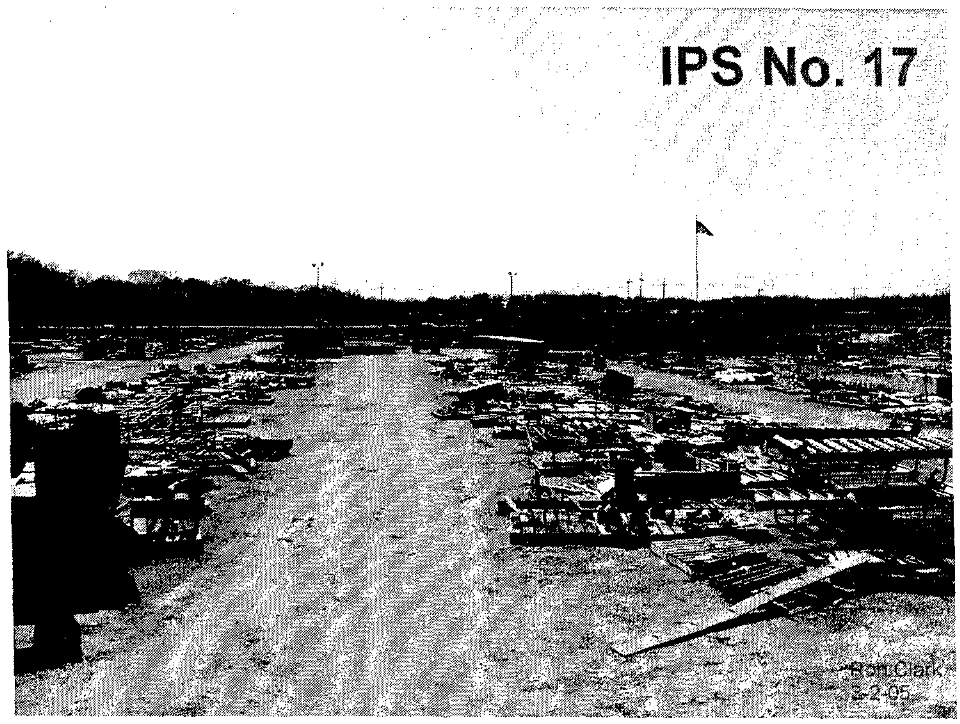
Receiving Area After



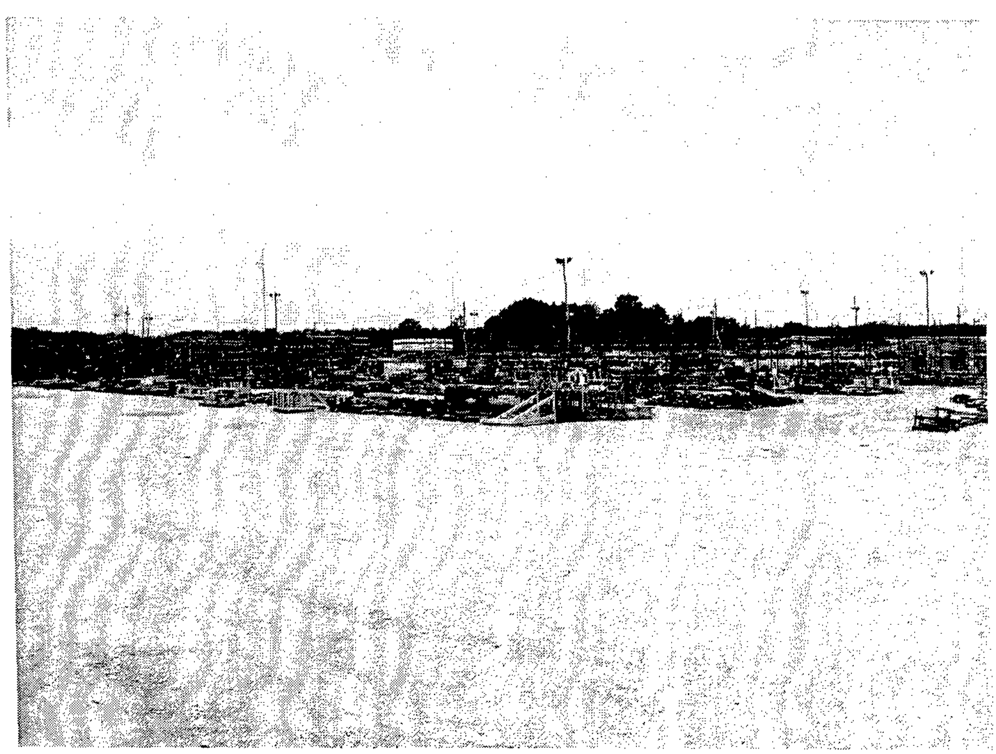
Lay Down Area Before



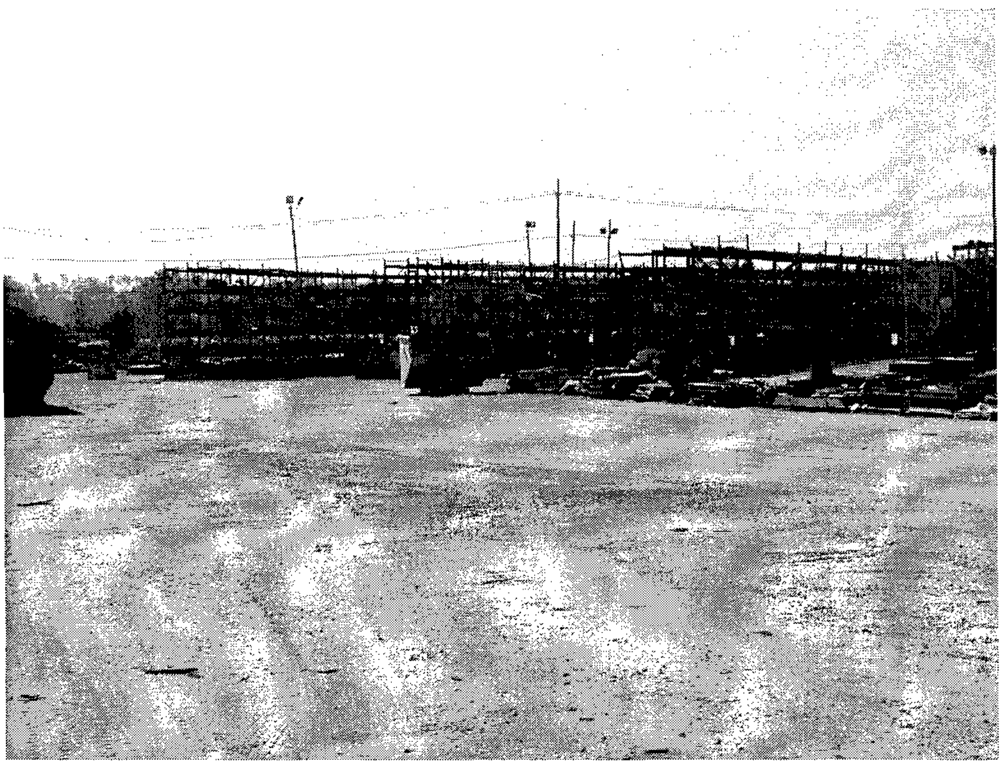
Lay Down Area After



Storage Area Before



Storage Area Intermediate Change



Storage Area After

1.8 WIPS to Dock

Any ordered material that is lost, misplaced or damaged between WIPS and the dock can cause:

- delays in scheduling,
- added overtime costs,
- compartment lock-outs,
- rework
- additional material expediting

Improvements to the processes which reduce any of these factors will eliminate the additional processes required to replace the material. This improves costs through reduced man hours, reduced material replacement, reduced lock-out costs, and reduced impacts to scheduling.

Some of the processes that require evaluation and improvement are those that increase/improve accountability and reduce storage/delivery locations. Accountability can be increased by creating control points for reviews and/or electronic or hardcopy signatures. A control plan, such as that either electronic or hardcopy. Each storage or delivery location which can be combined with another, eliminated entirely, or substituted for another will save handling and movement costs.

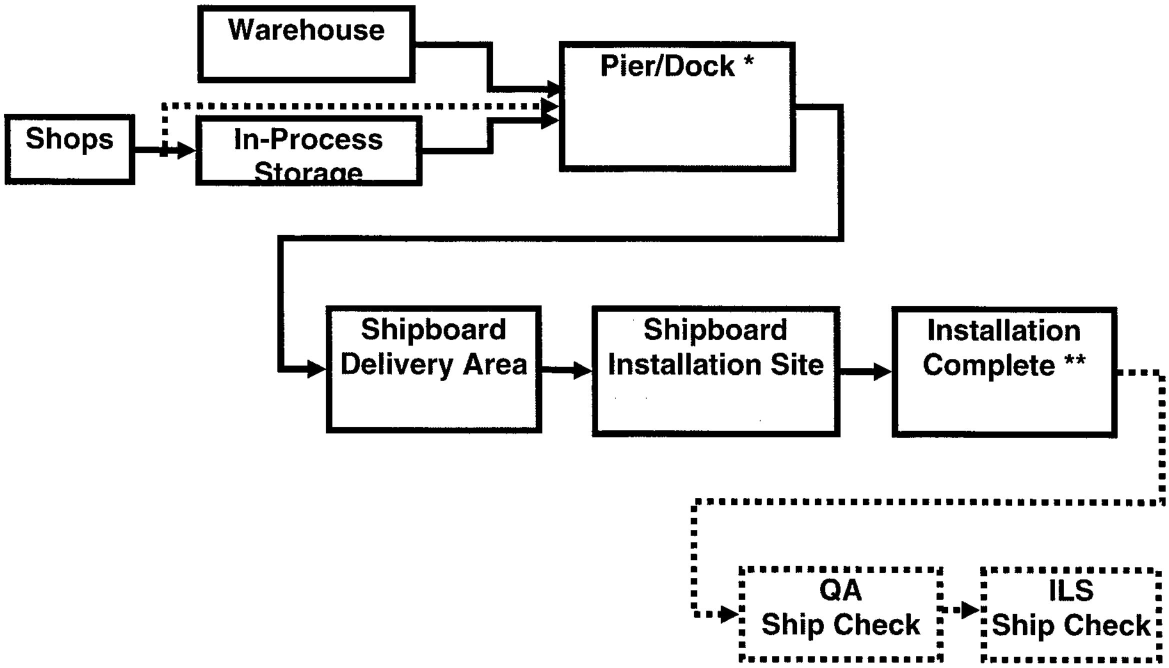
1.9 Move on ship

As has been found in the other areas, large amounts of time and money can be lost searching for, replacing and tracking material received from WIPS on Dock to Onboard Ship. This is a common occurrence on all vessels if there are no adequate/standardized receiving, staging, and tracking systems in place. The impact of lost or misplaced material may, due to re-work, be as much as 50% of the material costs. Schedule delays due to material unavailability may be over 50%. The more processes that are complete at the time of material loss, misplacement, or damage, the more cost is accrued. Therefore, it is pertinent to identify Root Cause of material delays and problems with the flow of materials from dock staging to onboard delivery.

It is critical that the visibility of material is not lost after delivery to Crafts because of system connectivity. Crafts may not have connection to the proper system(s) required for them to do their job in an efficient manner and work package may not contain a detailed step-by-step process from warehouse to installation. All of these may increase the misplacement of material.

There must be only one schedule. The schedule in the system may not be used for actual construction and it may not be detailed enough to use for daily status tracking. Therefore, to provide for needed details, multiple hidden schedules may be developed and be the fact not the exception. This situation may create:

- Materials ordering may be disconnected from the main schedule so a schedule change does not directly affect materiel ordering.
- Construction items may have been to the process area before they were complete and some uninstalled material became lost.
- Each manager uses a different system (log book, Excel, etc) to track materials and progress of jobs instead of common systems.
- Use of the centralized system for tracking part location may not be used in the Craft area.



High Level Flow from Warehouse to Ship

2 MATERIAL TRACKING

There are business issues relative to having the proper material tracking system in place. The first of these is a consistent and standard method of tracking materials from suppliers through fabrication to placement on board the ship as well as post delivery support. Without this consistency and standardization a multitude of labeling and tracking mechanisms may be developed which are not compatible.

A second issue is the fact that the utilization of existing systems may not be effective. As an example it has been found that existing bar code systems may not be fully utilized. The system may have more capability than is being realized or, it may not be as robust as was originally hoped. Therefore the system scope must be evaluated to determine if an adequate number of readers/scanners exist, the locations of these reviewed, and that proper data is being collected and effectively utilized. To make these issues are adequately covered, a full functional requirements definition is required to determine the appropriate system capabilities.

A consistent method of tracking materials from "cradle to grave" within the supply chain utilizing available technology (RFID, labeling with human readable and 2D bar code and mobile devices) will provide considerable benefits. These benefits include:

- Increased visibility of materials throughout the supply chain
- Ability to locate materials quickly
- Verification of material through the use of hand held mobile devices

- Availability of material identification, storage location, and move ticket information in real time
- Reduced pick time at storage locations
- Reduced misplacement/loss of material and parts re-fabrication
- Reduced paperwork through automated data capture

One of the basic aspects of material tracking is having a clean and orderly work area. Material is less prone to being misplaced in an environment that is structured and neat. Therefore, it would be beneficial to any operation to incorporate a 5-S program i.e. Seiri (Sorting), Seiton (Systematic Organization), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain). Establishing and maintaining such a program will, of itself, aid in material tracking and help make any tracking system more effective.

2.1 IT Technology

The Information Technology group must supply support as required to assist in the development of any material movement control and tracking system. The system definition, which includes the requirements of the system, the strategy taken for the development of the requirements, and the metrics to be applied to the systems is the responsibility of IT.

The IT group will review the parts (raw material, purchased components, fabricated components, equipment, etc.) all along the supply chain, from ordering though delivery of the ship, to develop the system parameters and requirements. IT will also determine the applicability of the system to other organizations such as: change control/management, configuration management, ILS, life cycle, etc. The evaluation of any tracking system will include system hardware/software, RFID hardware/software, application needs, availability/ scalability, as well as ease of integration into the existing legacy system with growth expectations for future ERP expansion requirements or implementation.

IT will determine and advise as to the best implementation partner(s) to provide the final defined system based on competitive and appropriate offering, industry expertise, enterprise knowledge, as well as proven supplier relationships

2.2 Technology Overview

Advanced tracking technology (ATT) enables the automatic capture of source data, thereby enhancing the ability to identify, track, document, and control equipment, personnel, and material.

ATT is one of the keys to obtaining, creating, capturing, and passing accurate and timely information on the status of assets, whether in-storage, in-process (during manufacturing or repair), or in-transit from the vendor and ultimately to the user. ATT is an enabling tool to facilitate the creation of machine-readable data (bar codes, RFID tags or contact memory buttons as examples), capturing the ATT data with a machine-readable device (bar code/RFID scanner or

contact memory button reader/writer), and then transmitting or transferring the ATT data so it can be aggregated and viewed in an enterprise network

- Bar Codes
- Bar Code Printers
- Bar Code Scanners
- Smart Cards
- Magnetic Stripe Cards with associated reader/writers
- Contact Memory Buttons with reader/writers
- Radio Frequency Identification tags (active and passive) with interrogators
- Biometrics consisting of fingerprint, face in a fingerprint, facial recognition, hand geometry, infra-red detection etc).

ATT can create source data (bar codes for example), collect or capture the data (bar code scanner), pass the data (wireless networks) and allow for the data to be aggregated and viewed at the automated information systems (AIS) or management information system (MIS).

ATT can improve the business processes and enhance production capabilities by:

- Facilitating the collection of initial source data
- Reducing processing times
- Improving data accuracy
- Minimizing personnel intervention
- Enhancing asset visibility.

Multiple ATT media are currently in use within the government and industry. These media are scanned, read or interrogated using a variety of means, including contact (Smart Card, magnetic stripe and contact memory Cards), laser (bar codes and optical memory), and radio frequency identification (RFID).

2.3 Purpose

It is the purpose of identifying technologies and defining opportunities to integrate Advanced Tracking Technology (ATT) into logistics business and operational processes to become more efficient and cost effective. ATT will serve as a tool to facilitate the collection of initial source data, reduce processing times, improve data accuracy and enhance asset visibility.

2.4 ATT Application Standards in Other Industries

Over the past few years, the ATT Industries have developed internationally accepted format and syntax for ATT devices and applications. Some these standards are as follows:

> **ANSI MH10.8.2** Data Application Identification Standard is an industry standard mapping technique. The Electronic, Aerospace, Automotive and other industries plan to use this technique to facilitate the automation within the manufacturing, distribution and

post sales operations. For example, **the EIA/ANSI PN 3497** product marking standard that calls for a two-dimensional bar code symbol with standard information such as supplier code, part number, and serial number.

ANSI MH10.8M, (industry standard shipping label) makes use of a PDF-417 symbol and linear bar code symbol. The linear bar code symbol is an internal tracking/traceability number and Electronic Data Interchange (EDI) look-up. The data encoded in the PDF-417 is trading partner specific. These are just a few examples of how industry has adopted the MH10 mapping scheme into specific application standards.

The Automotive Industry Action Group (AIAG), Aerospace Industry and Telecommunications Industry have endorsed **ANSI MH10.8M** for unit loads and the **EIA PN 3497** for parts marking. The Health Industry Business Communications Council (HIBCC) has recommended 2D for small containers, wristbands, patient health Cards, and individual unit dose. As you can see there is a clear synergy surrounding the ANSI and EIA standards by industry. The DoD can optimize its use of ATT by endorsing and participating in these standards efforts.

National Institute of Standards and Technology (NIST) publishes a document known as FIPS 140-2, "Security Requirements for Cryptographic Modules". This concerns physical security of a smart card chip, defined as a type of cryptographic module.

2.5 ATT Media and supporting technologies

2.5.1 Bar Codes

A bar code is a symbol that represents a group of characters. A reader scans the symbol, decodes it, and transfers the data to an Automated Information System (AIS). Bar codes are a means to collect data about items moving in the logistics chain and provide the data to AISs. Two general types of bar codes—linear and 2D—are used by the Defense Logistics Agency (DLA) and have been fully integrated into their nodes of the DoD logistics chain. Linear bar codes have limited data storage capacity and rely on the existence and availability of an AIS database; 2D bar codes have greater data storage capacity and can transfer complete data records to AISs. The following subsections briefly address bar codes.

2.5.1.1 Linear Bar Codes

Linear bar codes are one-dimensional bar codes; in other words, the information is carried in only one direction—left-to-right—and represents a limited group of characters. Linear bar codes usually are used to identify a key identifying data element such as national stock number (NSN), document number, or transportation control number (TCN). Bar-coded data are best used as an automated key to information that is pre-positioned in an AIS database. For example, an operator at a supply support activity (SSA) can scan a linear bar-coded document number on a DLA-created DD 1348, Issue Receipt Release Document, accompanying a shipment and obtain immediate access to the complete requisition data in the supply AIS. DLA uses two types of linear bar codes—Automatic Identification Manufacturers' BC-1 Code 3 of 9 (Code 39) and

Interleaved 2 of 5 (I 2 of 5). *Best use.* Linear bar codes are best used as an automated key to pre-positioned data in a database.

2.5.1.2 Code 3 of 9

A discrete, variable length, bar code symbology encoding the characters 0 to 9, A to Z, and the additional characters "-" (dash), "." (Period), Space, "$" (dollar sign), "/" (slash), "+" (plus sign), and "%" (per cent sign), as well as a special symbology character to denote the start and stop character, conventionally represented as an "*" (asterisk). Each Code 39 symbol consists of a leading quiet zone, a start symbol pattern, and symbol characters representing data, a stop pattern, and a trailing quiet zone. Each Code 39 character has three wide elements out of a total of nine elements. Each symbol consists of a series of symbol characters, each represented by five bars and four intervening spaces. Characters are separated by an intercharacter gap. Each element (bar or space) is one of two widths. The values of the "X dimension" and "N" remain constant throughout the symbol. The particular pattern of wide and narrow elements determines the character being encoded. The intercharacter gaps are spaces with a minimum nominal width of 1X. See *ISO/IEC 16388*. Applications include Supply, Personnel, Transportation, and Maintenance.

8137919805

Code 3 of 9

2.5.1.3 Interleaved 2 Of 5

Federal Express (FedEx) is a principal user of Interleaved 2 of 5 bar codes. DLA prints these bar codes on labels for FedEx shipments. Figure 2-3 displays three types of linear bar codes that encode the numeric sequence 1234567890. Although these codes are superficially similar, Interleaved 2 of 5 is significantly different from Code 39 and Code 128. Applications include Markings for shipping containers and air baggage.

2.5.1.4 Code 128

A continuous, variable length, bar code symbology capable of encoding the full ASCII 128 character set, the 128 extended ASCII character set, and four non-data function characters. Code 128 allows numeric data to be represented in a compact double-density mode, two data digits for every symbol character. Each Code 128 symbol uses two independent self-checking features, character self-checking via parity and a module 103 check character. Each Code 128 symbol consists of a leading quiet zone, a start pattern, characters representing data, a check character, a stop pattern, and a trailing quiet zone. Each Code 128 character consists of eleven 1X wide modules. Each symbol character is comprised of three bars alternating with three spaces, starting with a bar. Each element (bar or space) may consist of one to four modules. Code 128 has three unique character sets designated as Code Set A, B, and C. Code set A includes all of the standard upper case alphanumeric keyboard characters, the ASCII control characters having an ASCII value of 0 to 95, and seven special characters. Code set B includes all of the standard

upper case alphanumeric keyboard characters, lower case alphabetic characters (specifically ASCII character values 32 to 127), and seven special characters. Code set C includes the set of 100 digit pairs from 00 through 99, inclusive, as well as three special characters. The FNC1 character in the first character position after the start code of Code 128 designates that the data the follows complies with the UCC/EAN-128 standards. See *ISO/IEC 15417.* Applications include Supply, Transportation, and Maintenance.

Although DoD recognizes Code 128, there are no DoD Code 128 applications.

2.5.1.5 Two-Dimensional Bar Codes

Two-dimensional bar codes or symbologies get their name from the fact that they store data in two directions: left-to-right and top-to-bottom. They can store significantly more data than linear bar codes, facilitating more complex applications. Although most linear bar-code applications require the existence and availability of an external database to support business processes, 2D symbols may function as portable data files that travel with a shipment. They can sustain considerable damage and still be read. These characteristics are valuable in support of military operations. 2D bar codes are best used in Portable Data Files (PDF) applications where the data needs to accompany an item and the bar code needs to be readable.

2.5.1.6 Portable Data File (PDF) 417 2D Bar Code

DoD accepts the **PDF 417** bar code as the standard 2D bar code. Every PDF 417 symbol is composed of a stack of bar-coded rows, from a minimum of 3 rows to a maximum of 90 rows. A symbol can encode up to1,850 characters. DoD initially used PDF 417 bar codes on Military Shipping Labels (MSL) during the DoD Logistics ATT Operational Prototype in 1998–1999. DLA distribution sites now print them on all MSLs. PDF 417 bar codes are used to store and transfer some Transportation Control Movement Documents (TCMDs) and Issue Receipt Release Document (IRRD) data for individual shipment, as well as for consolidated shipments that involve eight or fewer line items. The number of line items may be subject to change, depending on circumstances. FedEx Ground Package Systems Inc. (formerly RPS Inc.) also uses 2D bar codes. DDC is considering adding these unique 2D bar codes to FedEx Ground Package Systems labels already being printed. Independent of an external database, 2D bar codes printed by DLA on MSLs carry and transfer key information required to process or transport an item. For example, an airman at the Dover aerial port who is checking in cargo from a Defense depot scans the linear bar-coded TCN on the MSL. The TCN is used as a reference number to TCMD data previously advanced to the aerial port AIS from the depot's AIS. Without the TCMD data, the shipment will be delayed. If the advance TCMD data fails to reach the aerial port AIS, the airman can scan the 2D bar code on the MSL and populate the aerial port AIS with the bar-coded TCMD data, so the shipment will not be frustrated. Applications include Supply, Personnel, Transportation, and Maintenance.

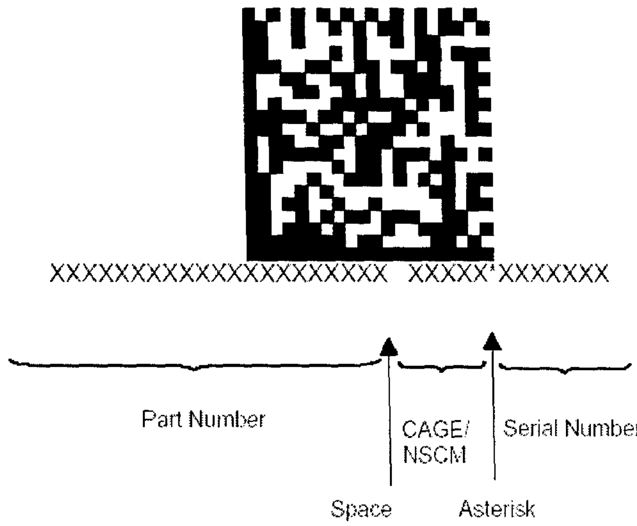
PDF 417

2.5.1.7 MaxiCode

MaxiCode is a medium-capacity matrix symbology that is specially designed for the high-speed scanning application of package sorting and tracking. It was introduced in 1992 by the United Parcel Service (UPS), which still uses it. The American National Standards Institute (ANSI) recommends MaxiCode in ANSI MH10.8.3M as the most appropriate 2D symbol for sorting and tracking. Although DoD accepts MaxiCode as the standard for logistics sorting applications, there are no DoD applications.

2.5.1.8 DataMatrix

DataMatrix is an error correcting two-dimensional matrix symbology, developed in 1989 with finalized design in 1995 by International DataMatrix, capable of encoding various character sets including strictly numeric data, alphanumeric data, and all ISO 646 (ASCII) characters, as well as special character sets. The symbology has error detection and error correction features. Each DataMatrix symbol consists of data regions that contain nominally square modules set out in a regular array. A dark module is a binary 1 and a light module is a binary 0. There is no specified minimum or maximum for the X or Y dimension. The data region is surrounded by a finder pattern that is surrounded by a quiet zone on all four sides of the symbol. The finder pattern is a perimeter to the data region and is one module wide. Two adjacent sides are solid dark lines used primarily to define physical size, orientation, and symbol distortion. The two opposite sides are made up of alternating dark and light modules. These are used primarily to define the cell structure but can also assist in determining physical size and distortion. There are two types of DataMatrix symbologies: ECC 000 - 140 with several available levels of convolution error correction, and ECC 200 that uses Reed-Solomon error correction. For ISO/IEC JTC 1/SC 31 purposes, only ECC 200 is recommended. The intellectual property rights associated with DataMatrix have been committed to the public domain. See *ISO/IEC 16022*. Applications include Supply, Personnel, Transportation, and Maintenance.



2.5.2 Radio Frequency Identification Technology (RFID)

RFID technology provides operators with a means to remotely identify, categorize, and locate materiel automatically while in transit. Data are stored digitally on RFID transponder devices, such as tags or labels. Remote interrogators (located a few inches to more than 300 feet from the transponder device) electronically retrieve the data via electromagnetic energy (radio or microwave frequency) and send the data to an AIS. RFID technology is divided into two categories of data storage and retrieval systems – passive and active.

- Passive systems generally have a limited range, requiring *line-of-sight* interrogation of powerless, inexpensive, low-capacity (20 byte) transponder devices. With the advent of improving technology, passive systems are approaching the performance characteristics of active systems.
- Passive systems have been tested and they offer capabilities that are applicable to military logistics applications.
- Active systems are omni directional and require moderately expensive, high capacity (126 kilobytes) transponder devices. Active technology has three characteristics that are significant for military operations.
  - First, RFID tags are effective portable databases.
  - Second, the tags facilitate rapid transfer of data to an AIS.
  - Third, active technology offers the only standoff, omni directional capability to collect data at distances of 300 feet or greater.

DoD first used active RFID technology in 1993 to provide in-transit visibility (ITV) during ocean retrograde of munitions and equipment from Europe. Since that time, RFID has supported exercises, contingency operations, and movement of selected sustainment seavans and air pallets. DoD adopted the 1993 Joint Total Asset Visibility (JTAV) RFID tag format as an interim standard. RFID provides not only ITV of tagged shipments but, when required, standoff content visibility of tagged shipments and the ability to locate shipments by triggering an audio device in the tag. These latter two characteristics are important to the Army for supporting contingency

operations. The United States Army Strategic Logistics Agency (now called the U.S. Army Logistics Integration Agency [LIA]) entered into an agreement with DLA headquarters in May 1993 to generate RFID tags on Army air line-of-communication pallets and seavans supporting forces in Somalia in 1993. LIA and DLA have expanded the use of RFID tags since that time to support special exercises, contingencies, and routine sustainment operations for selected customers. The concept for using RFID starts with "burning tags" at the CCP. This process involves transferring AMS IRRD commodity data and TCMD transportation data to the tag at a tag docking station. The tag data are sent concurrently to a regional ITV (RITV) server. The server creates a file for the tag. Users of the regional server (e.g., DLA customers—logistics commanders, managers, and operators) can access this file. The RITV server also transmits the data to the Global Transportation Network (GTN) and the JTAV systems. Customers also may access these systems for ITV data on tagged shipments. When a tagged shipment departs the depot, an RFID interrogation system remotely records and reports the tag's identification number and the date and time of the interrogation to the RITV server that updates the tag file. RFID is best used when a user needs stand-off, in-the-box visibility of container contents or in an austere environment with an inadequate systems or communications infrastructure.

2.5.3 Radio Frequency Data Communications (RFDC)

RFDC is an ATT- enabling technology rather than an ATT medium. It is a means for transferring data in real time among AISs and ATT media. In the absence of a hard-wired local area network (LAN), RFDC provides a wireless LAN that enables operators to access and update AIS databases remotely with two-way radio communications. RFDC enhances the utility of ATT by permitting operators to establish remote real-time interface between ATT devices and the supported AIS, using HHTs to:

- Collect and pass data from ATT media and update an AIS database;
- Extract data from an AIS database remotely and apply the data to a bar code, OMC Card, RFID tag, or other ATT medium;
- Eliminate batch downloading of data collected and stored in a portable HHT;
- Extract data from an AIS database, view the data on the HT's screen, and use the information to support business processes; and
- Reduce dependence on manual processing and printed documents.

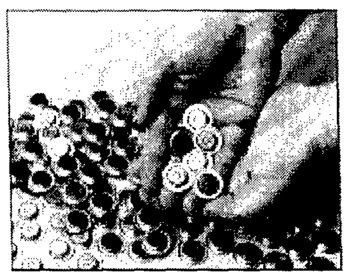
RFDC is best used to transmit source data in real-time from several subsystems to an AIS host system where cabling is not practical or desirable.

2.5.4 Contact Memory

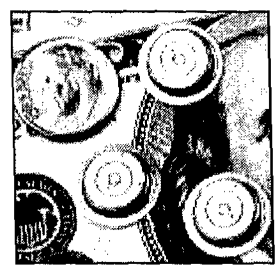
This technology is based on a contact memory button with EEPROM (Electrically Erasable Programmable Read Only Memory). A button is a very small, fast, read-write data storage device that is impervious in most harsh operating environments and has capacities of 128 bytes to 8 mega bytes. A button may not require a battery to retain its memory. Non-battery versions used by the Navy have a life expectancy of 100 years—or 1 million read-write cycles. Buttons work with portable button-readers or serial links that provide interfaces with personal computers.

Buttons cannot be read remotely. The Navy's applications of Contact Memory Buttons (CMB) include maintaining maintenance records on aviation components, calibration data on electronic components, and helicopter logbooks and associated technical manuals with aircraft. Button-Memories come in a variety of memory capacities; from 32k bytes down to 16 bytes, all Button-Memories are able to survive extreme conditions.

Button-Memories use EEPROM technology rather than battery-powered memory. Each time a Button-Memory is read, it is given a charge; this extends data retention for another 100 years.



ButtonMemory®



MiniButton™

2.5.5 Intelligent Labels (Passive RFID)

This technology is based on an ultra-thin, battery-less, RFID read-write transponder that is easily laminated between layers of paper or plastic. Unlike RFID tags, intelligent labels are a passive RFID technology with a limited range; they require interrogation of powerless, inexpensive, low-capacity transponder devices. Intelligent labels are ideally suited for identifying items quickly and accurately at close ranges. Intelligent labels are part of an RFID system that uses readers and antennas to capture and transfer data embedded in the label to AIS. Intelligent labels are limited to 256 bytes of memory.

DLA successfully demonstrated an application of backscatter RFID intelligent labels, 2D bar codes, and RFDC technologies to improve supply chain management of hazardous materials (HAZMAT) in April 2000. The Advanced HAZMAT Rapid Identification, Sorting, and Tracking (AHRIST) demonstration project was the first DOD application of intelligent labels. It revealed that HAZMAT items, tagged with intelligent labels, arriving at the depot on pallets of mixed cargo could be rapidly identified when passed through a stationary RFID portal. RFID enabled the hazardous cargo to be identified and separated. 2D bar-coded AHRIST data were scanned and downloaded to a simulated Defense Supply System (DSS) to support subsequent storage segregation, handling, and shipping processing. By ensuring that the presence of HAZMAT is readily recognized and that critical technical information about it is reliable and immediately available, the technology enables personnel to take appropriate actions to mitigate the risk associated with HAZMAT handling and ensure full compliance with federal, state, and local laws.

2.6 Smart Cards (Also known as Common Access Cards (CAC)

Smart Cards, or Integrated Circuit Chip (ICC) Cards, are plastic Cards the size of standard credit Cards with an imbedded microprocessor chip, built-in logic capability, and 1K to32K (currently) of Electronic Erasable Programmable Read Only Memory (EEPROM). Businesses and government's worldwide use Smart Cards for applications in banking, health care, transportation, security, benefit delivery, and identification. Smart Cards are more advanced than magnetic stripe technology, bar codes, and other portable storage media. ICC Cards' computer chips allow information to be stored securely on the Card rather than in a central repository. In this sense, the Card acts as a portable, relational database and can transport data between systems. Because the Cards have self-contained processing capabilities, they enable local or off-line transactions between the Card and host terminal or computer. Unlike bar codes and most portable data storage media, information residing on the Card can be continually updated or modified. Smart Card devices used to read data on the Cards can also be used to write data to the Cards. Card data can be managed for multiple purposes and applications through data partitioning and segregation. Card operating systems provide data security through the use of keys, passwords/PIN, biometrics, and encryption processes. The Card has sufficient physical space to include older technologies (e.g. magnetic stripe and bar code), a verifiable personal photograph, and the ICC.

2.7 Satellite-Tracking

Commercial satellite-tracking systems provide the ability to track near-real-time location of vehicles, materiel, and convoys and offer a digital communication capability to drivers. A system to track trailers or containers typically requires five components - a transceiver unit, a satellite, an earth station, a vendor network control center (NCC), and a DoD logistics AIS. The military organization and AIS receiving the data are the focal points of satellite tracking; they are called a satellite-tracking operations center. A transceiver unit is installed on a vehicle or container that is being monitored. This unit exchanges information with an earth station via satellite communications. The earth station is connected to the NCC that serves DoD and commercial users; the NCC stores information in electronic mailboxes for customers to access or continuously downloads data to the user's AIS through dedicated lines.

2.8 Potential ATT applications

2.8.1 Configuration Management

Configuration Management is responsible for identifying all configuration items and systematically controlling their changes, versions, and releases, thereby maintaining integrity and trace ability throughout the continuous Life Cycle of the item. Policies and requirements for Configuration Management for should be detailed in a Configuration Management Plan (CMP). Certain procedures in the CMP such as Physical Configuration Audit (PCA), Configuration Status Accounting (CSA), and Change Control offer excellent opportunities to use ATT. Further explanations of these areas follow:

2.8.2 Physical Configuration Audit

The Physical Configuration Audit (PCA) is used to examine the actual configuration of the CI that is representative of the product configuration in order to verify that the related design documentation matches the design of the deliverable Configuration Item (CI). It is also used to validate many of the supporting processes that the contractor uses in the production of the CI. The PCA is also used to verify that any elements of the CI that were redesigned after the completion of the FCA also meet the requirements of the CI's performance specification. In cases where the Government does not plan to control the detail design, it is still essential that the contractor conduct an internal PCA to define the starting point for controlling the production design and to establish a product baseline.

2.8.2.1 Configuration Status Accounting

Configuration Status Accounting is the process of creating and organizing the knowledge base necessary for the performance of configuration management. In addition to facilitating CM, the purpose of CSA is to provide a highly reliable source of *configuration information* to support all program/project activities including program management, systems engineering, manufacturing, software development and maintenance, logistics support, modification, and maintenance.

In addition to the standard Hierarchal Structure code (HSC) used throughout the Navy for Configuration Status Accounting (CSA) purposes, recent developments in industry and DoD have established several other programs that provide enhancements to configuration management process.

2.8.2.2 Electronic Product Code (EPC) Network

The EPC Network is an enabling technology that should make NGSS Configuration Status Accounting more effective through true visibility of information about Configuration items that make up the actual configuration of the ship as well as items that are in the supply chain. This new, open global standard combines low-cost RFID technology, existing communications network infrastructure (i.e. the internet etc.), and the Electronic Product Code (a number for uniquely identifying an item) to create cost-efficient, real-time, accurate information about the location of items, the history of items, and the number of Configuration items and items throughout the supply-chain. It is based on research conducted through the Auto-ID Center with the support of 100 leading companies and DoD.

<u>How the EPC Network Works</u>
The EPC Network is comprised of five fundamental elements:

2.8.2.3 EPC

The Electronic Product Code (EPC) is the next generation of product identification. Like the UPC (Universal Product Code) or bar code, the EPC is divided into numbers that identify the *manufacturer, product, version and serial number.* But, the EPC uses an extra set of digits to identify unique items. The EPC is the only information stored on the EPC tag. This keeps the cost of the tag down and provides flexibility, since an infinite amount of dynamic data can be associated with the *serial number* in the database.

2.8.2.4 EPC Tags and Readers

The EPC Network is an RFID-based system that uses radio frequency to communicate between readers and tags. The EPC (a number for uniquely identifying an item) is stored on a special tag. These tags should be applied during the manufacturing process. In turn, using radio waves, the tags will "communicate" their EPCs to readers which will then pass the information along to a computer or local application system.

2.8.2.5 Object Name Service (ONS)

The vision of an open, global network for tracking goods requires some special network architecture. Since only the EPC is stored on the tag, computers need some way of matching the EPC to information about the associated item. That's the role of the Object Name Service (ONS), an automated networking service similar to the Domain Name Service (DNS) that points computers to sites on the World Wide Web.

2.8.2.6 Physical Markup Language (PML)

The Physical Markup Language (PML) is a new standard "language" for describing physical objects. When finalized, it will be based on the widely accepted eXtensible Markup Language (XML). Together with the EPC and ONS, PML completes the fundamental components needed to automatically link information with physical products. The EPC identifies the product; the PML describes the product; and the ONS links them together. Standardizing these components will provide "universal connectivity" between objects in the physical world.

2.8.2.7 Savant

Savant is software technology designed to manage and move information in a way that does not overload existing corporate and public networks. Savant uses a distributed architecture, meaning it runs on different computers distributed through an organization, rather than from one central computer. Savants are organized in a hierarchy and act as the nervous system of the new EPC Network, managing the flow of information.

2.9 DoD Unique Identification of Tangible Items

A memorandum from the Under Secretary of Defense dated 29 July, 2003 establishes policy for the Unique Identification (UID) of Tangible Items – New Equipment, Major Modifications, and Re-procurements of Equipment and Spares. This memorandum provides guidance and establishes the requirements for UID. The UID Number and Advanced tracking technology devices provide and excellent configuration Management tool. The following is an outline of the policy:

UID is a mandatory DoD requirement on all contracts issued on or after January 1, 2004. An item must be uniquely identified if it is:

(1) Greater than $5,000 in acquisition cost;

(2) A piece of equipment or a reparable item less than $5,000 in acquisition cost that is either serially managed, mission essential or controlled inventory;

- **Serially Managed** – Includes reparable items down to and including sub-component reparable unit level; life-limited, time-controlled. Or items requiring records (e.g., logbooks, aeronautical equipment service records etc.); and items that require technical directive tracking at the part level (Deputy Under Secretary of Defense (Logistics & Material Readiness) Memorandum, September 4, 2002 *Serialized Item Management (SIM)* (See Paragraph 3.2.1)
- **Mission Essential/Item Essentiality** – A measure of an item's military worth in terms of how its failure (if replacement is not immediately available) would affect the ability of a weapon system, end item, or organization to perform its intended functions. (DOD 4140.1-R).
- **Controlled Inventory** – Those items that are designated as having characteristics that require that they be identified, accounted for, segregated, or handled in a special manner to ensure their safeguard and integrity. Includes classified items (require protection in the interest of national security), sensitive items (require a high degree of protection and control due to statutory requirements or regulations, such as precious metals; items of high value, highly technical, or hazardous nature; and small arms) and pilferable items (items having a ready resale value or application to personal possession, which are especially subject to theft) (DOD 4140.1-R); and safety controlled items.

(3) A consumable item or material only if permanent identification is required. Existing government furnished property provided to contractors was exempt from this policy until January 1, 2005 when this policy became mandatory for all government furnished property incorporated into an end item. Unique identification will complement the Department's existing policy on *Serialized Item Management (SIM).*

A unique identifier is a set of data for tangible assets that is globally unique and unambiguous, ensures data integrity and data quality throughout life, and support multi-faceted business applications and users.

For the unique identification data elements to be "machine-readable" by any ATT device, they must be identified by some means such that the reader device can recognize, through its resident software, what data element it is reading. This is accomplished by employing the concept of "semantics", which is literally "the meaning of language". For the purpose of constructing machine-readable data elements, semantics take the form of data qualifiers. There are three types of data qualifiers being used by various industry sectors, they are:

(1) Data Identifiers (DIs) (Format 06) ISO/IEC 15434

(2) Application Identifiers (AIs) (Format 05) ISO/IEC 15434

(3) Text Element Identifiers (TEIs) ISO/IEC TS 21489

ISO/IEC International Standard 15418, Information Technology – EAN/UCC Application Identifiers and ASC MH 10 Data Identifiers and Maintenance, governs DIs and AIs. Air Transport Association (ATA) Common Support Data Dictionary (CSDD) defines TEIs. ISO/IEC International Standard 15434, Information Technology – Syntax for High Capacity ADC Media, contains formats for DIs and AIs.

These data qualifiers have to define each data element placed on the item to tell the ATT devices how to derive the unique identifier.

2.9.1 ATT in the SHIPALT and change control process

SHIPALT material should be equipped with advanced automated information tags prior to being installed onboard ship. These tags would initially contain planned configuration information. The tags will then be attached to their equipment counterparts and at this point in time, or a convenient future point in time, a configuration validation will be conducted comparing the planned information against the actual equipment.

A handheld reader that is capable of reading PDF 417 or DataMatrix 2D Bar Codes and down loading and reading data to and from Contact Memory Buttons will be used to update ATT devices. This data can be any changes or additions not in the initial planning data, or new data that was not previously available.

At this time the handheld device can interrogate the updated button and the updated data can be downloaded manually or transmitted through Radio Frequency Data Collection techniques and passed to the current Configuration Status Accounting tool

Automated Identification Technology (ATT) incorporated into the Configuration Management process will a developed and proven means to perform shipboard configuration and logistics data management tasks with minimal manual human intervention. ATT will enable configuration data to be integrated with other logistics management information via common data elements (i.e. Record Identification Number (RIN), Work Breakdown Structure (WBS), Repairable Identification Code (RIC) etc.), thus:

- Minimizing duplicative tasks
- Streamlining logistics management processes
- Eliminating manual tasks such as sight validations

As a result, ATT provides a solid Return on Investment (ROI) through supporting reduced manning concepts and the elimination of manual tasks, reducing human errors, reducing rework, and reducing the requirements for validations, verifications and audits. Data accuracy is increased, and timelines for data updates greatly improved.

Advanced tracking technology should be integrated into the Configuration and selected Logistics Management processes of NGSS to produce a more cost effective, streamlined management process, with accurate and timely data management processes.

2.9.2 ATT Devices for Configuration Management

An ATT device for each Configuration Item (CI) should be programmed with required configuration and logistics data and then affixed to the CI prior to installation.

Various ATT devices would suffice for automated Configuration Management. The ideal devices are passive or active RFID tags along with RFDC and AISs. The cost of active RFID tags and the requirements for batteries make them prohibitive as a cost effective means of ATT on ships. The DoD Overarching Wireless Policy and FIPS 140-2 further impede the implementation of RFID and RFDC aboard ship. RFID Tag technology (active and passive) is constantly being researched and upgraded, and will without a doubt be affordable and will meet all of the DoD requirements at a future date.

Secondary technologies are currently available and are very effective for configuration management and other logistics functions. These technologies, in priority are:

- CMBs (are ideal for retaining configuration data of functionally significant items. Configuration data that can be stored can range from Serial Numbers CAGE Codes and Repairable Identification Codes (RIC) to the most important one for our proposed process, the Record Identification Number (RIN). These data elements are common throughout a ship's configuration data, logistics support and overhaul planning data. CMBs files can be partitioned; password protected, zipped and can contain other non-configuration data. These other data files can contain any sort of digital data from technical manuals to drawings and even pictures and voiceprints.

- PDF 417 and DataMatrix 2D bar codes provide a very cost effective means to support Configuration Management. These bar codes can be printed for pennies on stick-on label plates, or can be photo engraved on a standard Navy label plates (See below). These label plates can contain the item's configuration and logistics records (CDMD-OA Record Type 2s and 3s), plus other critical data that the CDM or Navy might require. Examples of this data might be things such as Safety Precautions or data such as what pump an ABT might feed, etc.

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B-Coder Demo

Standard Navy Label Plate with added PDF 417 2D Barcode

These bar codes should prove invaluable when conducting a required Physical Configuration Audit. Forty (40) of these barcodes can be printed on a single sheet of 81/2 X 11 paper. Each bar

code contains a complete Validation Aid. The cost for 2000 Validation Aids is somewhat insignificant. The value of such a simple item to every day processes and procedures is self-evident.

DataMatrix 2D bar codes have recently been adapted by the DoD and may very well have a large part in DoDs Unique Identification (UID) Policy. Although they have a smaller capacity than PDF 417, they are scaleable (down to less than ¼ inch). This trait makes them desirable for configuration management on smaller items (circuit boards etc.). DataMatrix is an ideal back up to CMBs and PDF 417s, and can be used in the same manner as the PDF 417 described above.

2.10 ATT in the DoD Supply Chain

Shipyards involved in DoD contracts should comply with and adhere to the requirements of the draft DoD memorandum dated 30 January 2004. The use of RFID in the DoD, and the Navy ship supply chain has the potential to provide real benefits in inventory management, asset visibility, and interoperability in an end-to-end integrated environment. The memorandum provides business rules for the use of high data capacity active RFID and an initial set of business rules for the implementation of passive RFID and the use of the Electronic Product Code (EPC) compliant tags within the DoD supply chain. DoD notes that this policy will continue to be refined over the next 12 months as active RFID, and passive RFID pilots are implemented.

2.10.1 Passive RFID Business Rules (Commencing January1, 2005)

2.10.1.1 Case/Pallet Level Tagging/Marking

1. All cases/warehouse pallets of materiel in all DoD classes of supply (except bulk commodities such as sand, gravel or liquids) should be tagged at the point of origin (manufacturer/vendor) with passive RFID tags at the case/pallet level (2^{nd} level packaging).

2. DoD sites where materiel is associated into cases/warehouse pallets will tag these materiels and supplies with an appropriate passive RFID tag at the case/pallet level (2^{nd} level packaging) prior to further trans-shipment to follow-on DoD organizations, Agencies, or Services.

2.10.1.2 Item Level Tagging/Marking

1. All items that require a Unique Identification (UID) , and items specified by the procuring activity, will be tagged on the item packaging at origin (manufacturer/vendor) with a passive RFID tag.

Note: Specific tag orientation and location, as well as physical mounting requirements are being reviewed and will be addressed in forthcoming revisions to both this policy and the appropriate DoD documentation.

2.10.1.3 Contract/Solicitations Requirements

All solicitations for materiel issued after October 1, 2004 for delivery on or after January 1, 2005 contain a requirement for passive RFID tagging at the case, pallet (2^{nd} level packaging) and UID item packaging level in accordance with an appropriate DFARS Rule/Clause.

2.10.1.4 Technical Specifications

The following table outlines the specific focus of this policy by RFID layer and identifies the tag type, tag class, and DOD approved frequency of the tags along with the nominal read ranges.

RFID Layer	Description	Tag Type	Class Tag	Frequency	Read Range	Requirement
0	Item	Passive	1 or 2	860-960 MHz	3 m	Not yet Required
1	Item Package	Passive	1 or 2	860-960 MHz	3 m	Required on UID/specified items Jan 1, 2005
2	Transport Unit, case,	Passive	1 or 2	860-960 MHz	3 m	Required 1 Jan 2005
3	Unit Load, pallet,	Passive	1 or higher	860-960 MHz	3 m	Required 1 Jan 2005

RFID tag specification:

1. When available, the DoD will use the EPC Class 1, Generation 2 tag.
2. Until the EPC Class 1, Generation 2 tag is available; the DoD will accept current EPC tags for tests, pilots, and initial implementation projects.
3. Initially, the DoD will require a tag utilizing a 96-bit tag for items acquired in accordance with the passive RFID business rules.
4. The ultimate goal for the DoD is to use an open standard, EPC compliant tag that will support DoD end-to-end supply chain integration.

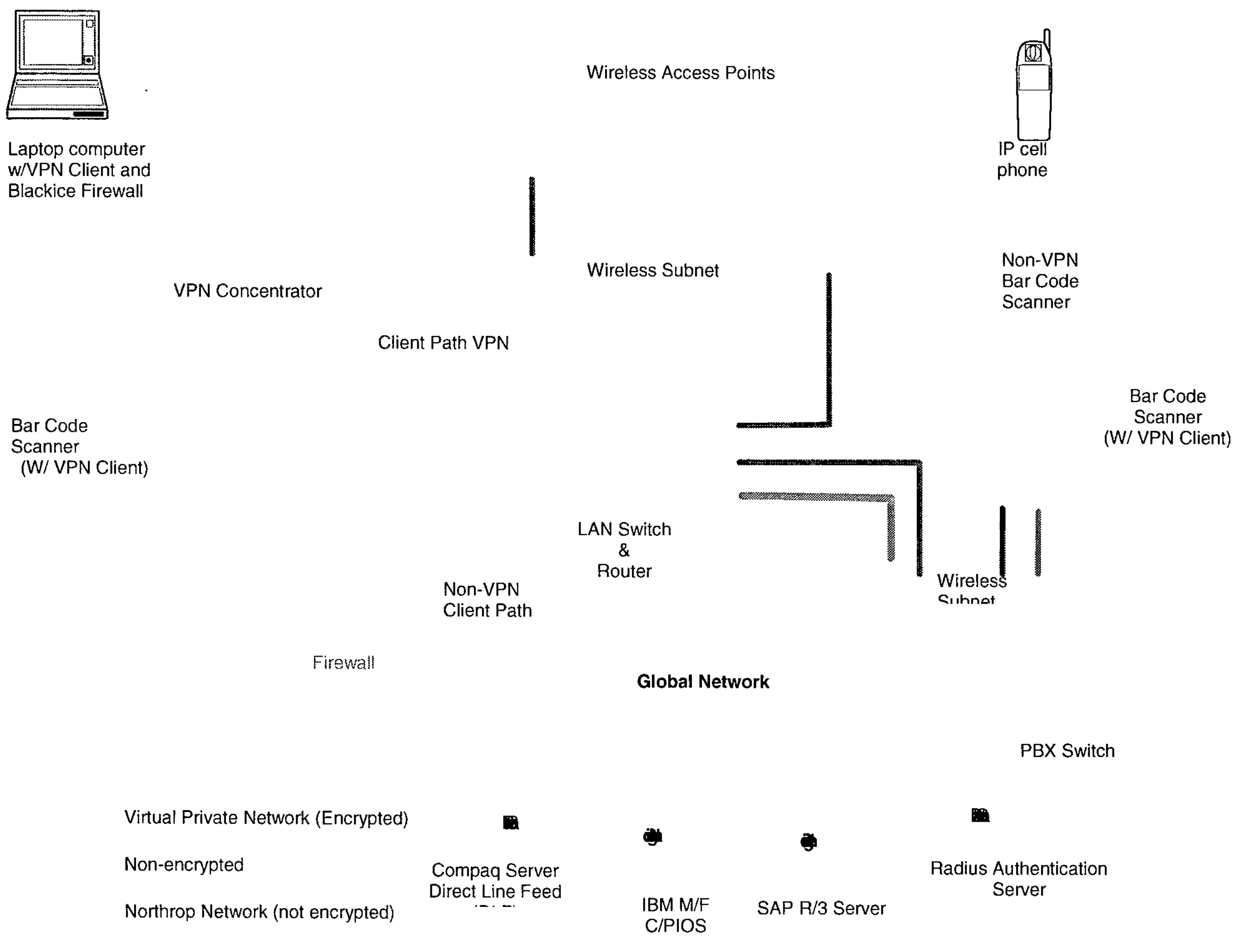
2.11 Wireless LAN (WLAN)

A Wireless Local Area Network (WLAN) is a shared resource that offers opportunities to the user community to access multi-use applications. From a holistic view, the wireless network should be designed with the proper architecture to minimize risk. It should adhere to the Information Security (I/S) Wireless Network Architecture Security Policy and should be comprised of the following measure to ensure the proper security safeguards are in-place:

- Basic Field Coverage - Confine the RF field to premises using directional antennas, because of wireless leakage, one of the first principals to basic field coverage is to only provide coverage for the areas that you want to have access. By using directional antennas and lowering the transmit power (on commercial class equipment - i.e., Cisco and Lucent), 85% (or higher) of the typical 802.11 signal leakage can be significantly confined.
- Treat Wireless LAN Access Points (WLAPs) as Untrusted - From a network security architecture, the WLAPs should be evaluated and determined if it should be treated as an untrusted device and need to be quarantined before the wireless clients can gain access to the internal network.
- Virtual Private Network (VPN) – is a protocol which encrypts data at the sending end (i.e., barcode scanner, PC, PDA, etc.) and decrypts it at the receiving end (i.e., VPN Concentrator) send the data through a "tunnel" that cannot be "entered" by data that is not

properly encrypted. An additional level of security involves encrypting not only the data, but also the originating and receiving network addresses.

- Radius Authentication Server – is an encrypted protocol, and supports the encrypted exchange of credentials between the remote end-user and the Authentication Server. User credentials (i.e., user-ids and password,) are forwarded to a Radius server that manages a Credential database. It is the Radius server, rather than an individual remote access server's, which carries out authentication.
- Firewall - an electronic blocking mechanism that will not allow unauthorized intruders into a computer system. A firewall is a combination of software, hardware and policy which exists to control access to information on either side of the firewall.
- Intrusion Detection Systems (IDS) – a system that is used to determine if a computer network or server has experienced an unauthorized intrusion.



3 INTEGRATED SUPPLY CHAIN SYSTEM CONCEPT

An integrated Barcode/RFID solution tracks product movement in the manufacturing and distribution facilities, takes advantage of RFID pallet and case tagging, and begins to leverage the ROI potential of RFID. The imbedded MS PowerPoint presentation below conveys some a potential for a pilot.

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3.1 Requirements

The return on investment for any automated data collection system is derived from reducing non-value-added tasks and making value-added tasks more efficient. This can be summarized in the following general needs statements:

- Streamlining the basic warehouse logistics functions
- Eliminate time spent doing manual data entry and dealing with paper based forms
- Eliminate subsequent clerical tasks such as filing, data entry / transcription
- Eliminate costs and errors associated with manual data entry and after-the-fact or second hand data entry
- Faster, more accurate and timely data collection and reporting capabilities
- Immediate information at the point of activity
- Reduced customer and departmental cycle times
- Warehouse staff and truck drivers spend less time spent waiting – reduced overtime
- Improved working conditions and personnel attitude
- Reduce paper and printing costs

Selection of the handheld hardware should be based on the following selection criteria at a minimum:

Selection Criteria
Wireless Standards Supported:
- 802.11a
- 802.11b
- 802.11g
Barcode Symbologies Read:
- Code 39
- Code 128
- Data Matrix
Operating System (Windows CE minimum)

Virtual Private Network (VPN)
Integrated RF Radio
Factory Hardened
Ergonomic (light, easy to handle)
Optional handle with trigger scan
Alphanumeric Keyboard
High Read Rate (> 99% FTRR)
Battery/ Backup (retain system config.)
Remote Download (system upgrades)
Dual 802.11a/b chipset

3.2 Benefits:

- **Increased shipping speed**
- **Fewer pick errors**

With RFID, pallets 'know' their product mix. RFID portals can warn drivers if they are loading the incorrect product into a trailer.

- **No staging**

Smart pallets can move from warehouse storage directly into a trailer. RFID tracks each product pallet loaded onto the trailer and generates an electronic manifest of the trailer contents.

- **Dynamic pick lists**

Drivers can be issued a pick list (electronically on a forklift terminal) for an order, grab the appropriate pallet, and drop it in the trailer. As each item is loaded into the trailer, the RFID system automatically reads the RFID tag and 'checks off' the pick list.

- **Increase Receiving Accuracy**

RFID will automatically scan incoming product pallet loads and allow you to cross reference the invoice to the shipment.

Even if you use trailers to store raw materials, you can use RFID to denote use and receipt of a supplier raw material. If the supplier offers Kanban techniques, they can use the 'return pallet' RFID scan as a reorder notice to ensure the manufacturing lines are maintained with enough raw material.

- **Supplier Integration**:

Incoming raw materials are captured when received. The RFID Tags are presented to the enterprise data systems to validate / cross reference the supplier advanced shipping notice.

When raw materials are depleted and the shipping containers for those materials are destroyed, the trash compactor or 'outgoing' RFID portal notes the resource depletion. This destruction notice is sent to the existing enterprise system and can be used as part of a Kanban design.

- **Internal Process Tagging**:

When the pallet build operation is complete, the software takes an 'RFID snapshot' of the Carton RFID Tags on the pallet. The software then produces a pallet tag which is applied to the finished pallet of products. This is called 'containerization' and anytime we see that pallet tag we know it 'contains' a bunch of carton tags.

The pallet tag and associated carton tags are stored on the server. This information is available for integration with the enterprise systems.

- **Storage and movement**

When an RFID-Enabled pallet is needed by a customer or moved to the warehouse, the pallet tag is scanned by the handheld RFID scanner and loaded on to a trailer. Optionally, the 'Shipping Portal' can be set to a specific order pick list and green/red lights on the portal will tell the forklift operators if an invalid item is being loaded onto the trailer. Each pallet loaded onto a trailer is added to the trailer manifest. This manifest can be integrated to the enterprise systems to create an ASN or a simple inventory transfer for internal product movement.

3.3 Barcode Symbologies

The three barcode symbologies, Code 39, Code 128 and DataMatrix are those that will typically be required to meet current and future requirements including those specified in the DoD's UID Policy. All equipment purchased for a compatible system needs to support these barcode symbologies.

3.4 Wireless Network Standard

Any existing network standard in current use should be migrated to the 802.11g standard as products become available and the need for improved performance is required. The 802.11a/g standards are new emerging standards that should be approved in the near future.

3.5 Access Points

The 802.11b and 802.11g access points can coexist on the same WLAN, however they will all transmit at the lower transmission speed of 802.11b (11Mbps) and the full potential of the 802.11g transmission rates (54Mbps) will not be realized. Therefore all the 802.11b access points will have to be upgraded to 802.11g before the higher transmission rates can be obtained.

3.6 Barcode Scanning Equipment

The barcode scanning equipment currently available in the marketplace supports the barcode symbologies (Code 39, Code 128 and Data Matrix). These symbologies will satisfy the current needs and future requirements as specified in the DoD's UID Policy.

All barcode scanning equipment purchased in the future should be capable of reading Code 39, Code 128 and DataMatrix with the same device. A preliminary assessment of scanners indicated that devices from Dolphin, Intermec and Symbol would satisfy the UID Policy requirements. Minimizing the variants used should provide for lower total costs through potential for greater discounts, lower support costs and shared usage of equipment.

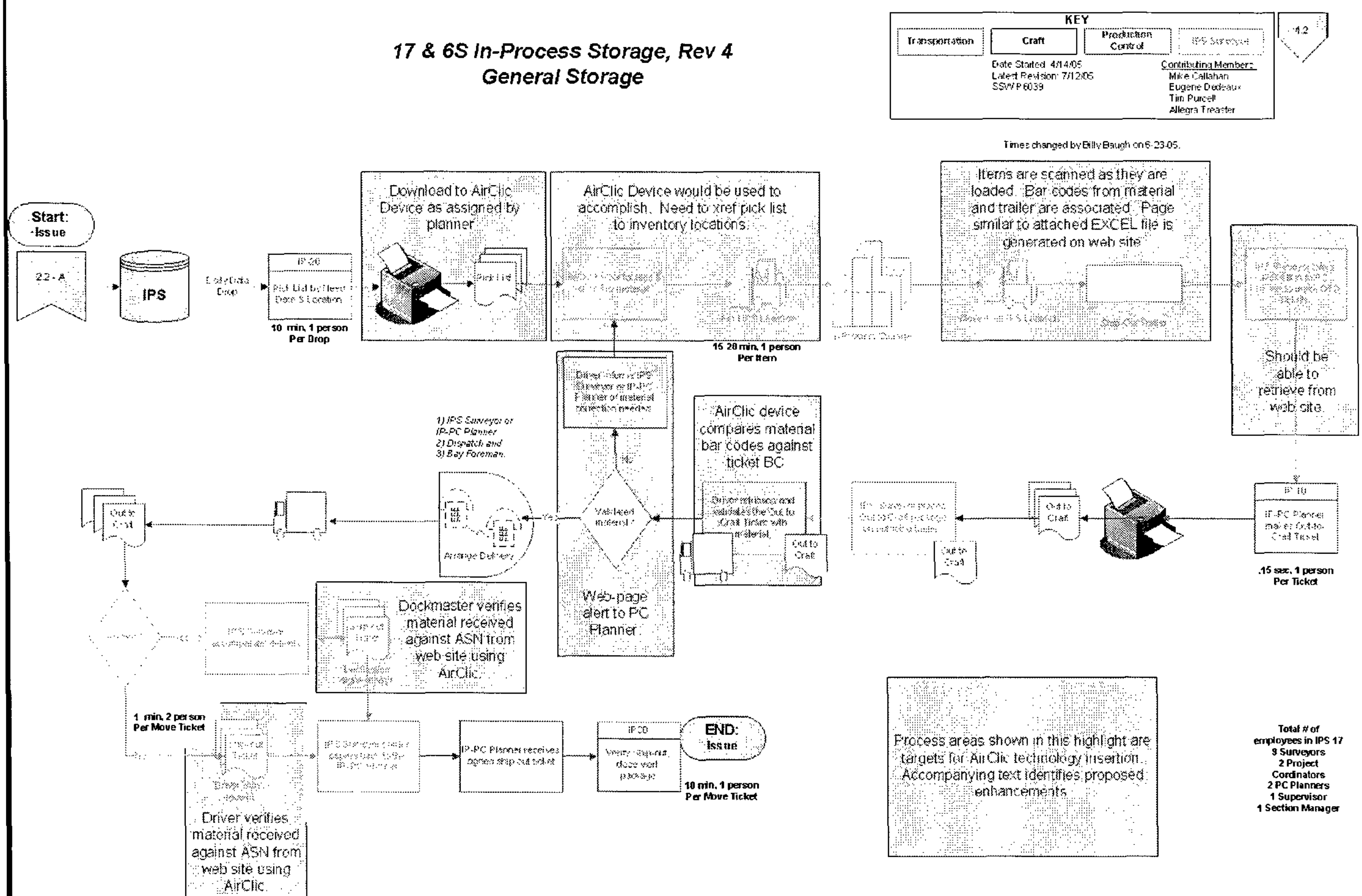
3.7 Barcode Labeling & Marking Equipment

The barcode labeling & marking equipment currently available in the marketplace supports the barcode symbologies (Code 39, Code 128 and Data Matrix). These symbologies will satisfy the current needs and future requirements as specified in the DoD's UID Policy.

Procurement of the necessary barcode labeling equipment and/or outsourcing its product/part marking requirements to a supplier should both be considered in the development of a strategy.

3.8 Recommended Pilot Architecture

Below is a Value-Stream map (VSM) of a material movement scenario with markups indicating the technology insertion points for a pilot project.



Approved for Release. Distribution is unlimited.

The bar-coding portion of a pilot could best be accomplished through the use of an engineered, middleware-based hardware/software system. One such solution is provided by the Sylogist Corporation.

An alternative solution especially well suited to a proof of concept pilot is provided by AirClic. This solution utilizes Nextel handsets and the Nextel network to provide a third-party database-enabled website from which two-way transactions can be passed to and from the Java-based handset equipped with an add-on barcode scanner.

4 OTHER INDUSTRIES

Other industries were surveyed to ascertain how they tracked and monitored materials within their operations. These included aircraft, automotive, construction, airlines, and package delivery. It was found that, while retail operations were starting to utilize RFID tags, the use of these tags had not permeated the other industries surveyed. This is probably due to the fact that the government customer is driving the use of RFID on Navy contracts. The first push for RFID was on the LPD 17 contract requests for proposal. However, due to the status of the technology at that time, there were few suppliers. Therefore, the requirements were dropped.

Most industries differ from ship building in that their volumes are considerably higher, the size of parts handled are considerably smaller, and most do not have the "red tape" associated with government contracting.

4.1 Aircraft Manufacturing

Aircraft manufacturing has not embraced RFID to any noticeable extent. They have highly sophisticated manufacturing and material handling/movement systems that have evolved over years. These systems have efficient tracking and materials are monitored through each stage of the operation. The Aerospace Industry has endorsed ANSI MH10.8M for unit loads and the EIA PN 3497 for parts marking. Both of these standards are bar code based.

The two areas where RFID can make inroads are kitting and containerization. However, it may be sometime before such would occur since the current systems provide for bar code identification of the containers in which items are placed. Since the material used in the manufacture of aircraft lends itself to kitting into more easily handled containers and stored containers than that in shipbuilding due to material sizes, inside storage requirements and movement does not have the same implications as shipbuilding where items may be stored in open field areas where RFID would have benefit.

4.2 Airlines

While it would seem that airlines would be utilizing RFID tags to identify some of their conveyance mechanisms such as the aircraft or the luggage cart. However, airlines are still

relying on the standard bar code. It was also interesting to note that the airlines did not find it a necessity to acknowledge the pickup, by passengers, at the end of their trip.

4.3 Automotive

The automotive manufacturing groups are also staying with bar code marking. The automotive industry is using ANSI MH10.8.2 Data Application Identification Standard as their standard mapping technique. The Automotive industry plans to use this technique to facilitate the automation within the manufacturing, distribution and post sales operations. Also, product marking with a two-dimensional bar code symbol will be utilized. The Automotive Industry Action Group (AIAG), have also endorsed ANSI MH10.8M for unit loads and the EIA PN 3497 for parts marking. .

4.4 Construction

Construction is, and always has, been an operation which had constraints that: required Just In Time delivery of materials, in some cases did not know their total specific material needs until midpoint or later in the construction, and had limited storage space. This puts them closer to typical shipbuilding operations than most other industries. Construction firms have utilized Open Plan software to develop construction schedules and plans. However, Open Plan was structured for construction applications and does not handle some of the nuances of shipbuilding.

4.5 Package Delivery

While it was thought that package delivery operations may be heading towards RFID tag identification it is apparent, after reviewing the current processes used by UPS (MaxiCode bar code based system) and Federal Express (Interleaved 2 of 5 bar code based system), the existing processes are more than adequate for their operations. Due to the scanning of packages throughout the process, these companies know where each package is located. Packages are scanned upon entry into the system and as each package is handled, whether manually or through automation, constant scanning is taking place and systems updated with location data. The cost of upgrading all of their systems to go to RFID would, at this time, be more expensive then the benefits realized. However, application of RFID may offer some benefits to monitor the motor vehicles and aircraft onto which packages are loaded. This would allow the additional benefits of tracking those transportation equipments for maintenance purposes and loading the maintenance data and schedules into the RFID tag.